Iowa State University
Digital Repository

Retrospective Theses and Dissertations | Iowa State University Capstones, Theses and Dissertations

1969

An analysis of tall-grass prairie vegetation relative to slope position, Sheeder Prairie, Iowa

Robert Kenneth Kennedy
Iowa State University

Follow this and additional works at: https://lib.dr.iastate.edu/rtd

Part of the Agriculture Commons, Ecology and Evolutionary Biology Commons, and the Plant Sciences Commons

Recommended Citation

Kennedy, Robert Kenneth, "An analysis of tall-grass prairie vegetation relative to slope position, Sheeder Prairie, Iowa " (1969). *Retrospective Theses and Dissertations*. 334.
https://lib.dr.iastate.edu/rtd/334

This Thesis is brought to you for free and open access by the Iowa State University Capstones, Theses and Dissertations at Iowa State University Digital Repository. It has been accepted for inclusion in Retrospective Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.

,/ ~?

AN ANALYSIS OF TALL-GRASS PRAIRIE VEGETATION RELATIVE TO SLOPE POSITION, SHEEDER PRAIRIE, IOWA

by

Robert Kenneth Kennedy

A Thesis Submitted to the

Graduate Faculty in Partial Fulfillment of

The Requirements for the Degree of

MASTER OF SCIENCE

Major Subject: Plant Ecology

Approved:

Signatures have been redacted for privacy

Iowa State University
Of Science and Technology
Ames, Iowa

1969

QK99.P7
K3862

Page 587

TABLE OF CONTENTS

	Page
INTRODUCTION	1
LITERATURE REVIEW	6
METHODS	10
RESULTS	16
DISCUSSION AND CONCLUSIONS	40
SUMMARY	52
POSTSCRIPT	54
LITERATURE CITED	55
ACKNOWLEDGMENTS	57
APPENDIX	58

T21498

INTRODUCTION

Prairie vegetation in presettlement Iowa covered more than 80 percent of the land area (Moyer, 1953). With the arrival of white settlers, the rich prairie sod fell victim to the plow in almost direct proportion to the speed of the westward migration. A few prairie areas escaped plowing by virtue of being too wet for crops, inaccessible due to topography or an inconvenience. One early investigator (Shimek, 1925) of prairie vegetation in Iowa wrote,

> Comparatively little of the native prairie remains in Iowa. A few unbroken tracts are still scattered about over the state,...but even these have been more or less disturbed by pasturing and cutting.

Even under the strength of this early indictment the philosophy of the plow has not changed, and in recent years it has gained an ally operating as a public transportation facility. Shimek (1925) also observed this new threat commenting,

> Much of this native flora was also formerly preserved along the public highways, but this is rapidly dissappearing with the widening of the driveways on the primary roads and the enforcement of the unwise undiscriminating weed-laws of the state along secondary roads.

In 1933 an uneasy compromise was reached with the publication of the Iowa State Conservation Commission's Twenty-five Year Plan. This set of guidelines has resulted in the acquisition by the state of four prairie preserves: Hayden Prairie, in 1945; Kalsow Prairie, in 1948; Cayler Prairie, in 1960; and Sheeder Prairie, in 1961. It is this most recent acquisition, Sheeder Prairie, which is the subject of this investigation.

The objectives of this study have been defined in part on the criteria set forth by Moyer (1953) and somewhat modified by Ehrenreich (1957) for preliminary studies of prairie preserves. As both qualitative and quantitative information about a specific area preclude effective and meaningful management, the following objectives are prerequisite to any analysis of management techniques.

1. a record of species
2. a record of past use and disturbance
3. an indentification of plant communities relative to slope position
4. an identification of soil parent material relative to slope position and vegetation
5. a preliminary measurement of productivity relative to slope position

These objectives by no means exhaust the quantity of available or desired information, but they are well within the scope of a preliminary study which should provide an information base for the future in-depth study of soils, vegetation and management relative to Sheeder Prairie.

Sheeder Prairie is a 25 acre tract located in the S.W. corner of Sec. 33, Seely Twp., Guthrie Co., Iowa (Figure 1) and was purchased in 1961 from Oscar Sheeder, son of the original homesteader. Twenty-three acres of the tract are prairie with the exception of two small areas on the north border and a two acre buffer strip on the east. These plowed areas are easily identified due to soil compaction and a lack of floral diversity (Figure 2). The prairie is bordered on the south by a gravel road and on the north, west and east by fields which have been cropped for at least sixty years.[1]

The prairie has been mowed annually in late fall since about 1865[2]

---

[1]Oscar Sheeder. Guthrie Center, Iowa. 1969. History notes. Personal interview.

[2]Ibid.

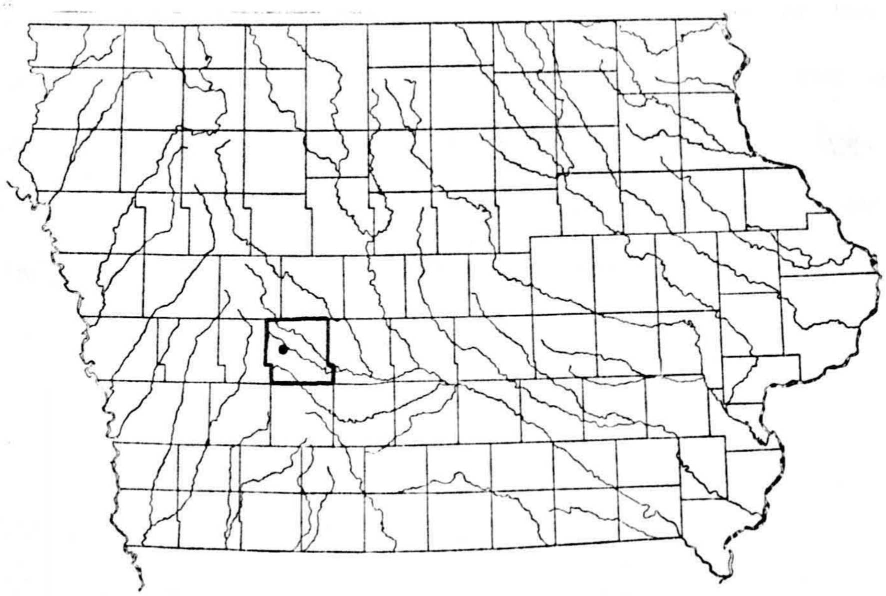

Figure 1. Sheeder Prairie location in Guthrie County, Iowa

Figure 2. Aerial photograph of Sheeder Prairie, October 7, 1968, facing north, with formerly plowed strips showing to the east, in the northeast corner and faintly along the north edge

until 1965, with the exception of 1963 when no hay was cut at the request of the State Conservation Commission. When mowing was done the hay was either stacked or baled. Evidence of a recent haystack site (ca. 1965) is still present in the form of distinct vegetation zones in the low alluvial area visible to the left center of Figure 2. Mowing was entirely discontinued after 1965. Grazing has never been intensive and was always of late fall occurrence. Cattle were allowed to wander onto the prairie from adjacent fall stubble fields.[1] This practice ceased when the prairie was fenced in 1961.

The first intentional fire occurred ca. 1890 in late fall after haying had been completed. Fire was used as a management tool under the same conditions about every third year, until 1946 when an accidental fire burned the entire prairie as well as three haystacks and one thousand bales.[2] The prairie has not been burned since 1946.

Sheeder Prairie is located in the Shelby-Sharpsburg-Macksburg soil association area, and its soils have developed generally from loess covered Kansan drift (Oschwald et al., 1965). Five parent materials are the basis for soil development on Sheeder Prairie. These are loess, glacial till, alluvium, till-derived sediment over till, and paleosol. The loess-derived Sharpsburg soils are present on the ridgetops and upland slopes of the prairie where the loess accumulation is about 30 inches. Shelby soils have formed on sideslopes from unweathered Kansan and Nebraskan till which has been exposed by slope truncation. Several areas of Adair soil are present

---

[1] Sheeder, op. cit.

[2] Ibid.

on ridgetops or downslope from the Sharpsburg soils. Adair formed from a re-exposed late Sangamon paleosol which developed during an inter-glacial weathering period of 100,000 to 125,000 years duration (Oschwald et al., 1965). A paleosol of post-Nebraskan origin was tentatively identified on the long nose slope where the altitudinal differential between crest and low point is 70 feet. This Aftonian paleosol would have formed over Nebraskan till during a post-glacial weathering period of 250,000 years duration (Oschwald et al., 1965).

The vegetation of Sheeder Prairie varies in relation to its position in a diverse landscape. The upland areas are generally dominanted by Little Bluestem, Andropogon scoparius,[1] and Needlegrass, Stipa spartea with Prairie Dropseed, Sporobolus heterolepis, scattered throughout and increasing downslope. Redroot, Ceanothus ovatus and the Upland Willow, Salix humilis, also characterize these relatively stable upland slopes. Big Bluestem, Andropogon Gerardii is scattered throughout the prairie with major occurrence on the lower slopes and alluvial areas. The larger drainage ways are dominanted by Box Elder, Acer Negundo. Associate species in these areas are Black Willow, Salix nigra and American Plum, Prunus americana, as well as several introduced herbaceous species.

---

[1]Nomenclature follows Gleason (c1952) except the Gramineae which follows Pohl (1966).

LITERATURE REVIEW

Early studies of the prairie association in the North American grassland formation were floristic without concern for environmental factors other than climate (Shimek, 1911, 1925). Within Iowa, Shimek (1925) documented species composition on several prairie sites, roadcuts, railroad rights-of-way, and an old stream channel because of his concern for restoration of prairie after disturbance in such areas. He concluded that prairie areas may be restored after disturbance and that the prairie represents a climax state, not a successional stage. Prior to this study Clements (1916) had proposed a classificatory system of plant succession in which he maintained that regional climate was the controlling factor in the persistence of the prairie association. Later, a study using climatological data collected over a 20 year period (Transeau, 1935) served to delimit, convincingly, the prairie peninsula, which includes over 80 percent of Iowa's land area. In contrast with earlier studies in Iowa, McComb and Loomis (1944) concluded that the Iowan prairie was presently subclimax; however, a recent study of soil strata using radio-carbon dating of buried plant materials and fossil pollen analysis (Ruhe and Scholtes, 1956) concludes that an environment conducive to prairie development has existed for the past 5000 years. During late Sangamon time (over 25,000 years ago) Iowa was predominately forested under the influence of a cool, moist climatic regime. This climate changed perceptably during Wisconsin time (24,000 to 11,000 years ago) to a cold, moist glacial regime interrupted by cool, moist intra-glacial periods. Some evidence exists that a 1500 year period (15,000 to 13,500 years ago) in mid-Wisconsin time supported a warmer grassland environment (Ruhe and Scholtes, 1956). They concluded that the soil landscapes in Iowa have had a forest environment from about 16,000 to 5,000 years ago and a prairie environment for the past 5,000 years.

Weaver (1954, 1968) has done extensive work with factors other than climate. In his book, North American Prairie, Weaver (1954) treats individual species and communities relative to topographic position in the prairie. This work also discusses plant-soil relationships, seasonal aspects, and the underground plant systems relative to growth habit and soil moisture. A more recent work (Weaver, 1968) summarizes fifty years of observation on the prairie and its environment centered in relict prairie areas near Lincoln, Nebraska. Site dominants were *Andropogon scoparius* on the upland and *Andropogon Gerardii* in the lowland areas. He concluded that the physiognomy, ecological structure and floristic composition of the tall-grass prairie remain relatively unchanged under wide variations in certain environmental factors; however, minor changes in the water relationships (soil moisture e.g. from ridgetop to midslope to lowland) were immediately recorded in the vegetation. An early account (Shantz, 1911), using native Colorado mixed-grass, compared short-grass, bunch-grass and wire-grass as indicators of soil moisture and subsequently crop success. He concluded that production of plant cover was a more reliable indicator of soil moisture than the presence or measurement of any single species. Conversely, a study done on a 100-acre bluestem prairie near Guthrie Center, Iowa (Weaver, 1958) showed that individual species respond strongly to changes in soil moisture. He found that a transition from *Andropogon Gerardii* to *Andropogon scoparius* took place about one-third of the way up the slopes and that the site dominants, *A. scoparius* and *A. Gerardii* accounted for 80 percent of the vegetation. He concluded that *A. scoparius* did not compete well with

A. Gerardii on the lower sites.

The implied relationship of soil moisture to vegetation was also examined in 65 stands of prairie vegetation in Wisconsin (Curtis and Green, 1949). The study gave indications of interrelationships between stands as opposed to the floristic examination of a single stand, an approach which gives no indication of the inter-stand variation. The stands were divided into four classes: upland, lowland, dry limey and sandy. Ten species, based on presence, were listed to characterize each class. Using percent presence data from the 65 Wisconsin prairies and literature values for stands from five other states, including Iowa, a remarkable uniformity in composition was found to exist. In subsequent years the concept of a prairie continuum was proposed (Curtis, 1955,1959; Curtis and Cottam, 1962) consisting of a two-dimensional ordination of stands along a moisture gradient from 100 to 500 based on the presence of certain indicator species within each stand. The methodology will be discussed in greater detail in the methods section of this paper. This method should be as applicable to intra-stand gradients as it is to inter-stand gradients. A recent application of the prairie continuum concept to Iowa vegetation covered five remnant prairies in the Ames, Iowa vicinity (Freckman, 1966). The range of these stands on the continuum scale was 235 to 398, with a value of 300 to be considered most mesic. He concluded, with reservations, that this system could be used to describe other Iowa prairies.

The Guthrie Center study (Weaver, 1958) showed the effect of disturbance on prairie vegetation. Any substantial increase in basal cover was nearly always due to an increase in disturbance (grazing or mowing) which subsequently led to an increase in Poa pratensis, an introduced species.

Poa pratensis occurred in surrounding pastures but was rarely over 1-5 percent abundance in the prairie until disturbance. Weaver (1958) commented,

> Slight invasion of the European species had resulted from annual mowing and removal of forage. This permitted fall light for growth of this cool season, rhizomatous grass both in early spring and late autumn.

A 15 year study near Lincoln, Nebraska on a bluestem dominanted pasture (Jensen and Schumacher, 1969) showed the effect of grazing on species composition. Species which decreased were Andropogon Gerardii, A. scoparius, Sporobolus heterolepis, S. asper, Stipa spartea and Sorghastrum nutans. Over the duration of the study, the two bluestems were reduced from 72% to 57% composition. Species which increased were Poa pratensis, Bouteloua curtipendula, Carex sp. and Panicum scribnerianum. Invading species were Bromus commutatus, Sporobolus cryptandrus, and Agropyron smithii. Hulett and Tomanek, (1969) working on bluestem dominanted relicts in Kansas, concluded that basic management practices must be based on an understanding of the soil, plant and climate interrelationships. A major source of information about these relationships is found in relict prairies which have not been subject to intensive grazing pressure. These areas provide support for many range management concepts (Hulett and Tomanek, 1969).

Other studies relating to management describe objectives which are not related to grazing, but to management for scientific use and aesthetics. Hayden (1946) was instrumental in documenting the criteria for use and establishment of prairie preserves. Ehrenreich and Aikman (1963) investigated the value of certain prairie management practices and Landers (1966) initiated the definition of basic objectives for preserve management in Iowa.

METHODS

Sheeder Prairie was selected as a study site for three reasons: (1) no compositional or floristic information was presently available; (2) the diverse topography provided an excellent opportunity to study native prairie vegetation relative to slope position; (3) an accumulation of basic information was prerequisite to effective management of the area.

A floral list for Sheeder Prairie was accumulated through a combination of periodic random cruising and a stratified random sampling grid (Brown, 1954; Oosting, 1956) arranged along two belt transects (Oosting, 1956) with a common point of origin. The transects were subjectively placed to maximize differences in altitude and soil parent materials. Transect dimensions were 20m x 230m (transect 1) and 20m x 280m (transect 2). The common origin was the highest point on both transects while low points were 70 feet lower on transect 1 and 45.2 feet lower on transect 2. Locations of the transects can be seen in Figures 3 and 4. To aid in the stratification of plots, redwood stakes were placed at 10 meter intervals to divide the transects into 10m x 20m units along a semi-permanent baseline. Each of these units was further subdivided into m^2 units with 100 units on each side of the baseline. Using a table of random numbers, two m^2 plots were selected for sampling each of the 100 m^2 units, totaling four m^2 samples per 10 meters of transect distance. Actual plot placement for the first three 10m x 20m units on transect 1 and the first 10m x 20m unit on transect 2 is shown in Figure 9 (Appendix) while Figure 10 (Appendix) shows the location of the origin.

Presence data were taken from m^2 plots in August-September, 1968, for transect 1 and September-October, 1968, for transect 1. Rooted presence was used with the exception of the clump-forming grasses which were considered

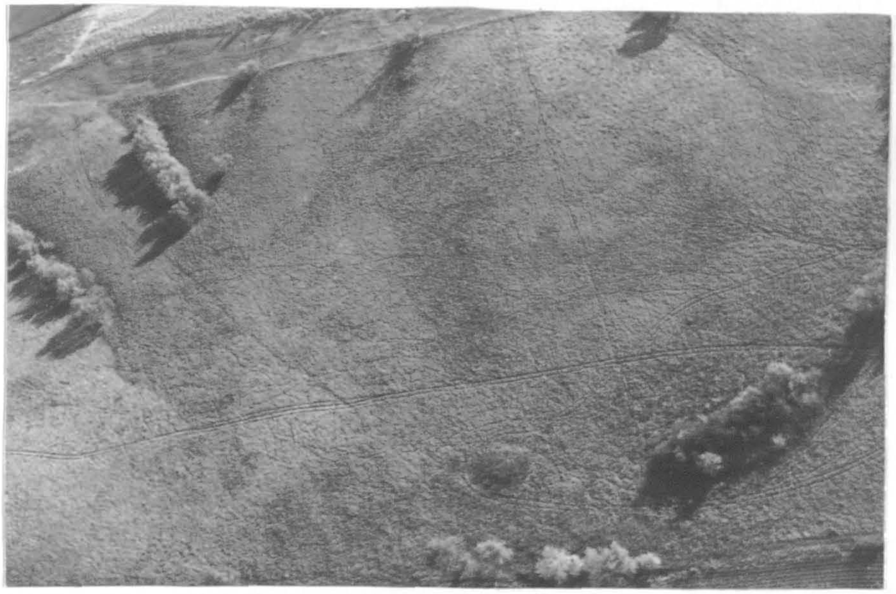

Figure 3. Aerial photograph of Sheeder Prairie, October 1968, facing east, with transect 1 running from the top-center toward the trees at the bottom-right of the photograph

Figure 4. Aerial photograph of Sheeder Prairie, October 1968, facing east, with transect 2 crossing diagonally from the top-right corner to the bottom-left corner of the photograph

present if any portion of the clump was within the m^2 frame.

Cover dominants or co-dominants were assigned in each m^2 plot using a modification of Daubenmire's cover class estimates (Daubenmire, 1959). A species was considered dominant if it fell into cover class 3 or higher and was taller than most of the other species in the plot.

cover class	% cover
1	0 - 5
2	5 - 25
3	25 - 50
4	50 - 75
5	75 - 95
6	95 - 100

Although cover was used to characterize dominance, species were simply listed as dominants for a plot, without designating a cover class.

Estimates of productivity were made by clipping one 20cm x 50cm ($0.1m^2$) plot in each 10m x 20m unit on both transects. The clipped plot was always on the left side of the baseline (facing down the transect from the origin) and placed at the bottom-left corner of the fourth m^2 plot in each 10m x 20m unit. Plant material was clipped at the ground surface, oven dryed at 80 C for 24 hours, and weighed to the nearest 0.5 g. After removal of the standing material, the plot was scraped down to the mineral surface and the litter collected in paper sacks. In the lab, this material was floated to separate soil particles from the plant material, oven dryed at 80 C for 24 hours, and weighed to the nearest 0.5 g. During the weighing process a dominant (referred to as mass dominant from here on) was recorded for each sample of standing material on the basis of observed bulk.

Using a hand probe, soil cores[1] were taken to a depth of 36 inches at

[1]A. H. Huddleston. Ames, Iowa. 1969. Soil Identification. Private Communication.

each 10 meter marker. A transit was used to determine the relative altitude at each 10 meter marker with the lowest point being arbitrarily assigned a value of 10 feet. Soil cores and altitude determinations formed the basis for the delineation of the transects into 18 stands (Table 4) which were used in the prairie continuum analysis (Curtis, 1955) and the species importance ordination.

The prairie continuum was used as a means of correlating vegetation with slope position. The continuum is based on the number of species present in each of five groups of ten indicator species each, which represent five site classes based on moisture gradient. The number of indicator species from each group is multiplied by the weighting factor assigned to that group and the products of all groups are summed.

Indicator group		Weighting factor
Wet	(W)	1
Wet-mesic	(WM)	2
Mesic	(M)	3
Dry-mesic	(DM)	4
Dry	(D)	5

This sum is divided by the number of all indicator species present and multiplied by 100 to give the prairie continuum index of the stand which ranges from 100 (wet) to 500 (dry). The continuum index was calculated for each of the 18 stands using absolute frequency, rather than presence, to place the 18 stands on a moisture gradient. This modified continuum index was calculated using the following formulae:

$$\text{(1)} \quad \text{absolute frequency} = \frac{\text{number of plots in which species occurred}}{\text{total number of plots in stand}}$$

$$\text{(2)} \quad \text{continuum index}_{(f)} = \frac{W_f + 2(WM_f) + 3(M_f) + 4(DM_f) + 5(D_f)}{W_f + WM_f + M_f + DM_f + D_f} \times 100$$

where:

W_f = sum of the frequencies of wet indicator species
WM_f = sum of the frequencies of wet-mesic indicator species
M_f = sum of the frequencies of mesic indicator species
DM_f = sum of the frequencies of dry-mesic indicator species
D_f = sum of the frequencies of dry indicator species

The continuum index for each of the 18 stands was compared with slope position to correlate with an assumed moisture gradient. To ordinate the soil parent materials, all similar units were grouped from both transects regardless of aspect, and the continuum indexes were calculated for all units of a stand. To qualify as a stand an area had to contain a minimum of 20 species including five of the Curtis indicator species.

In the species-importance method individual species are ordinated on a divaricate continuum which ranges from 0.001 to 0.999 and 1.000 to 320.0. A natural break in the continuum occurs between 0.999 and 1.000 as species which are non-dominants in a stand have values at or below 0.999 and increase in importance as they near 0.001. Species which are dominant in a stand have values at or above 1.000 and increase in importance as they near 320.0. Species importance values were calculated for all species which occurred in m^2 samples along each transect with the following formulae:

$$(3) \quad \text{frequency index} = \frac{\text{frequency of species A in the stand}}{\text{frequency of species A in the transect}}$$

$$(4) \quad \text{species importance value} = \frac{\text{number of plots in the stand in which species A is dominant} + 0.01}{\text{frequency index}} \times 10$$

The addition of 0.01 in equation 4 facilitates placement of species which are not stand dominants onto the continuum. Important species should represent stand indicators and thus characterize stands relative to slope position and parent material. Percent dominance was also calculated for use with productivity data and for evaluation of the species importance values as follows:

$$(5)\quad \text{percent dominance} = \frac{\text{number of plots in which species A is dominant}}{\text{number of plots in which species A is present}} \times 100$$

A third ordination method was used to show species relationships in three dimensions (Orloci, 1966). Raw presence data were transferred to computer punch-cards. Using the IBM 360 computer and a complex program involving computation in hyperspace (more than three dimensions), species were ordinated by Q-analysis by locating all species along an axis between the two most different species. Q-analysis ordinates species using locations as axes. A similar technique, R-analysis, ordinates locations using species as axes. The 56 species used had to be present in at least 5% of the transect plots or dominant in at least one plot. The numbers of locations used were 88 (transect 1) and 112 (transect 2).

RESULTS

A complete list of species observed during 1968-69 on Sheeder Prairie appears in Table 14 (Appendix). Species are arranged alphabetically by family, and common names are included. Selected families are compared in Table 1 as to their contribution to the prairie flora.

Table 1. Contribution of selected families to the floral composition of Sheeder Prairie

	number of			total species
	families	genera	species	percent
> two genera/family	8	75	112	62.2
Compositae		28	46	25.5
Gramineae		18	29	16.1
Fabaceae		10	15	08.3
Rosaceae		5	8	04.4
Umbelliferae		5	5	02.8
Labiatae		3	3	01.7
Ranunculaceae		3	3	01.7
Scrophulariaceae		3	3	01.7
two genera/family	8	16	18	10.0
one genus/family	38	38	50	27.8
Totals	54	129	180	100.0

Frequencies of individual species are shown in Table 2 for transect 2 and Table 3 for transect 1. Species most frequent on transect 2 included: *Stipa spartea*, *Panicum leibergii*, and *Andropogon scoparius*. The most frequent species on transect 1 were: *Panicum leibergii*, *Stipa spartea*, *Amorpha canescens*, *Phlox pilosa*, *Zizia aurea*, *Euphorbia corollata* and *Andropogon scoparius*. Eight species had frequencies below 01.5 % on transect 2 while transect 1 had 15 species in this range. Only *Lepidium campestre* and *Liatris aspera* had frequencies below 01.5% on both transects. Ninety-six (53.3%) of the 180 species observed on the prairie at large occurred in sample plots at least once.

Table 2. Species importance values for 10 stands on transect 2 arranged from left to right in order of slope position relative to the origin and including percent frequency for species encountered on transect 2

SPECIES	% frequency on Transect 2	1	2	3	4
Ambrosia artemisiifolia	03.6	---	---	---	---
Amorpha canescens	33.9	0.067	0.038	0.135	0.135
Andropogon Gerardii	22.3	---	0.178	0.267	---
Andropogon scoparius	61.6	0.061	0.082	24.722	16.509
Antennaria neglecta	11.6	---	0.030	0.139	---
Antennaria plantaginifolia	04.5	---	0.017	---	---
Artemisia ludoviciana	10.7	---	---	---	---
Aster ericoides	24.1	---	---	0.144	---
Aster laevis	17.0	---	0.135	0.067	0.033
Aster sericeus	09.8	0.039	---	0.058	---
Aster simplex	02.7	---	---	0.032	0.010
Baptisia leucophaea	01.8	---	0.014	---	---
Bouteloua curtipendula	09.8	---	---	---	---
Carex sp.	28.6	0.114	---	0.171	0.114
Ceanothus ovatus	25.9	10.459	20.919	17.779	0.051
Cassia fasciculata	16.1	---	---	---	---
Cirsium altissimum	10.7	---	---	0.064	0.021
Conyza canadensis	01.5	---	---	---	---
Coreopsis palmata	14.3	0.057	0.038	0.057	0.057
Desmodium illinoense	04.5	---	---	---	---
Echinacea pallida	27.7	---	0.221	0.041	0.110
Elymus canadensis	38.4	0.153	---	0.115	0.076
Elymus virginicus	04.5	---	---	---	---
Equisetum sp.	07.1	---	---	0.085	---
Erigeron strigosus	01.8	---	---	---	---
Eryngium yuccifolium	08.0	0.016	---	0.096	---
Euphorbia corollata	45.5	---	---	0.078	0.091
Fragaria virginiana	08.0	0.032	0.064	---	---
Gaura biennis	11.6	---	---	0.139	---
Helianthemum Bicknellii	04.5	0.008	0.011	---	---
Helianthus grosseserratus	00.9	---	---	---	---
Heliopsis helianthoides	07.1	---	---	0.028	---
Hieracium longipilum	08.0	---	---	0.096	---
Koeleria cristata	10.7	---	0.085	---	---
Kuhnia eupatorioides	04.5	---	---	---	---
Lactuca Serriola	02.7	---	---	---	0.010
Lepidium campestre	00.9	---	---	---	---
Lespedeza capitata	12.5	---	---	0.150	---
Liatris aspera	00.9	---	0.007	---	---
Liatris pycnostachya	00.9	---	---	---	---
Liatris squarrosa	05.4	0.010	0.042	0.064	---
Linum sulcatum	08.0	0.032	0.032	---	---
Lithospermum canescens	01.8	---	---	---	---

5	6	7	8	9	10
---	---	---	0.114	0.042	0.028
0.271	---	---	0.155	0.101	4.216
---	9.017	13.461	18.035	0.053	4.007
42.312	24.765	41.149	65.861	0.184	19.810
0.092	---	0.139	0.185	---	0.037
---	---	0.026	---	---	0.071
0.028	---	---	0.057	0.042	---
---	---	0.096	5.563	0.096	0.077
0.045	---	0.101	0.181	0.203	0.067
---	---	---	---	---	0.019
---	---	---	0.085	---	---
---	---	---	---	---	2.876
0.026	---	0.117	0.314	0.039	0.052
0.045	0.038	0.085	0.152	0.114	0.065
0.103	---	---	---	0.062	11.335
0.128	0.064	0.032	0.064	0.096	---
---	---	0.128	0.057	---	0.171
---	---	---	0.057	0.147	---
0.114	---	---	0.114	---	0.076
---	---	0.053	0.071	0.053	0.071
0.110	---	---	0.098	0.083	0.073
0.061	0.076	0.092	17.637	0.092	0.122
---	---	---	3.603	---	0.071
0.057	---	0.085	0.045	---	---
---	---	---	0.057	0.021	---
---	0.032	0.032	0.128	---	---
0.182	---	0.109	0.097	0.109	0.072
0.032	---	0.096	0.064	---	---
0.046	---	---	0.046	0.069	---
---	---	---	---	---	---
---	0.003	---	---	---	---
---	---	---	0.057	0.085	---
---	---	---	0.257	0.096	0.021
---	---	0.064	0.085	0.064	0.057
---	0.017	0.026	0.071	---	---
---	---	---	---	0.032	0.042
---	---	---	0.028	---	---
0.100	0.050	0.150	0.080	0.150	0.050
---	---	---	---	---	---
---	---	---	0.028	---	---
---	---	---	---	---	0.042
---	---	0.048	0.257	---	0.042
---	---	---	0.057	---	0.028

Table 2. (Continued)

SPECIES	% frequency on Transect 2	1	2	3	4
Melilotus officinalis	01.8	---	---	---	---
Muhlenbergia racemosa	09.8	---	---	---	---
Onosmodium occidentale	01.8	---	---	---	---
Oxalis europaea[a]	04.5	---	---	---	---
Panicum implicatum	08.0	---	---	---	---
Panicum leibergii	89.3	0.089	0.102	0.107	0.119
Pamicum virgatum	02.7	---	---	0.032	---
Petalostemum candidum[b]	19.6	---	---	0.117	---
Phleum pratense	00.9	---	---	---	---
Phlox pilosa	51.8	0.069	0.138	0.088	0.103
Physalis virginiana	00.9	---	---	---	---
Poa compressa	24.1	---	---	---	---
Poa pratensis	19.6	0.078	---	0.117	0.039
Polygonum scandens	00.9	---	---	---	---
Potentilla canadensis	00.9	---	---	---	---
Potentilla norvegica	10.7	---	0.085	0.128	---
Prunus americana	01.8	---	---	0.021	---
Rhus radicans	04.5	---	---	5.280	1.801
Rosa sulffulta[c]	12.5	---	0.050	---	---
Ratibida pinnata	42.9	---	0.342	0.128	---
Salix humilis	09.8	0.013	1.133	0.117	---
Setaria lutescens	00.9	---	---	---	---
Silphium integrifolium	37.5	0.150	0.060	0.150	---
Silphium laciniatum	07.1	---	---	---	---
Solidago canadensis	05.4	---	---	0.064	---
Solidago missouriensis	02.7	---	---	---	0.053
Solidago speciosa	13.4	---	---	---	0.053
Solidago rigida	02.7	---	0.010	---	---
Sorghastrum nutans	31.3	---	0.250	0.187	---
Sporobolus heterolepis	38.4	15.394	17.593	0.076	7.754
Stipa spartea	92.9	0.092	55.803	65.088	0.123
Ulmus rubra	01.8	---	---	---	---
Vernonia Baldwini	04.5	---	---	---	---
Viola pedatifida	01.8	---	---	---	---
Viola pedata	10.7	---	---	0.128	---
Zizia aurea	55.4	0.110	0.110	0.060	5.590

[a]Includes individuals of Oxalis stricta.

[b]Includes individuals of Petalostemum purpureum.

[c]A convenient taxonomic label for this often hybridizing group.

5	6	7	8	9	10
---	---	---	0.028	---	---
0.039	0.013	0.058	0.078	---	---
---	---	0.021	0.078	---	---
---	---	---	0.142	0.017	0.071
---	---	0.096	0.085	---	0.025
0.142	0.119	0.133	0.105	0.089	0.095
---	---	---	---	---	0.021
---	---	0.235	0.048	0.235	0.062
---	---	---	0.028	---	---
0.207	0.207	0.124	0.127	0.088	0.055
---	---	---	0.028	---	---
---	---	0.289	5.563	0.036	0.096
0.157	0.078	6.767	0.157	5.951	---
0.007	---	---	---	---	---
---	---	---	0.028	---	---
---	---	---	0.171	0.064	0.028
---	---	---	---	---	0.028
0.035	0.017	---	---	---	---
---	---	0.150	0.080	0.100	0.050
0.171	0.085	0.064	0.085	0.057	0.114
---	---	---	---	---	---
---	---	---	---	0.010	---
0.150	---	0.064	12.695	0.150	0.300
0.019	---	0.042	0.228	0.085	0.114
0.042	---	---	0.057	0.064	---
---	---	---	0.028	---	---
---	---	0.053	0.071	0.040	0.071
---	---	---	---	0.032	---
---	0.062	0.093	11.224	15.077	12.541
11.339	0.076	18.523	61.732	23.154	10.339
21.330	12.504	33.541	184.547	65.088	83.658
---	---	---	---	---	0.014
---	0.017	---	0.035	---	---
---	---	---	0.057	---	0.028
---	---	0.128	0.057	0.064	0.085
0.110	0.110	0.073	0.088	---	0.147

Table 3. Species importance values for 8 stands on transect 1 arranged from left to right in order of slope position relative to the origin and including percent frequency for species encountered on transect 1

SPECIES	% frequency on Transect 1	11	12	13
Acer Negundo	01.1	---	---	---
Achillea Millefolium	02.3	---	---	---
Ambrosia artemisiifolia	04.6	0.036	---	---
Ambrosia trifida	02.3	---	---	---
Amorpha canescens	80.7	0.092	43.119	0.088
Andropogon Gerardii	48.9	16.808	0.195	25.213
Andropogon scoparius	63.6	0.101	36.433	43.262
Antennaria neglecta	38.6	0.309	0.103	0.077
Antennaria plantaginifolia	20.5	0.163	0.065	0.122
Artemisia ludviciana	08.0	---	---	---
Aster ericoides	15.9	---	12.848	0.190
Aster laevis	25.0	---	---	0.300
Aster sericeus	14.8	0.059	0.118	0.035
Aster simplex	03.4	---	---	---
Baptisia leucantha	01.1	---	---	---
Baptisia leucophaea	02.3	0.018	0.036	---
Bouteloua curtipendula	10.2	---	0.163	---
Bromus tectorum	02.3	0.018	---	---
Carex sp.	13.6	0.109	0.218	---
Cassia fasciculata	37.5	0.300	0.600	---
Ceanothus ovatus	25.0	6.733	16.080	15.036
Cirsium altissimum	10.2	---	0.054	0.122
Comandra umbellata	01.1	0.009	---	---
Coreopsis palmata	26.1	0.104	0.046	0.156
Cornus stolonifera	01.1	---	---	---
Desmodium illinoense	03.4	---	---	0.013
Echinacea pallida	44.3	0.118	0.078	0.075
Elymus canadensis	13.6	0.054	0.109	---
Elymus virginicus	06.8	---	---	---
Eryngium yuccifolium	09.1	---	---	---
Euphorbia corollata	64.8	0.172	0.103	0.070
Fragaria virginiana	08.0	---	0.127	---
Geum canadense	01.1	---	---	---
Gaura biennis	05.7	0.045	---	0.068
Gentiana puberula	01.1	---	---	---
Helianthemum Bicknellii	05.7	0.022	---	---
Heliopsis helianthoides	04.5	---	0.072	---
Hieracium longipilum	35.2	0.281	0.070	0.105
Hordeum Jubatum	08.0	---	---	---
Juniperus virginiana	01.1	0.009	---	---
Koeleria cristata	23.9	0.095	0.127	0.057
Kuhnia eupatorioides	01.1	---	---	0.013
Lactuca biennis	05.7	---	---	0.017

14	15	16	17	18
---	---	---	---	0.013
---	---	---	0.027	0.027
0.072	---	---	0.027	---
---	---	---	---	2.738
0.080	0.080	9.313	10.866	0.484
0.130	---	0.390	41.104	51.381
74.139	8.569	25.517	11.022	77.158
0.068	0.038	0.077	0.115	---
0.109	---	0.163	---	---
---	---	0.063	0.031	0.031
0.254	---	0.063	0.047	0.047
0.045	0.025	0.040	0.300	0.150
0.078	---	0.118	---	---
---	---	---	---	0.013
---	---	0.009	---	---
---	---	---	---	---
---	0.020	0.020	0.061	---
---	---	---	---	0.027
0.109	0.027	---	0.032	0.163
0.100	0.075	0.042	0.045	0.075
8.080	---	0.200	---	---
0.081	---	---	---	0.040
---	---	---	---	---
0.139	---	0.104	0.104	0.156
---	---	---	---	0.013
---	---	---	---	---
0.141	0.059	0.070	0.132	0.177
---	0.054	0.036	0.081	0.081
---	---	---	0.081	1.658
0.048	0.018	---	0.036	---
0.079	---	0.129	0.077	0.129
0.127	---	0.063	0.095	0.031
---	---	---	---	0.013
---	---	---	0.068	0.034
---	---	0.009	---	---
0.090	---	---	---	---
---	---	---	0.054	0.027
0.062	---	0.070	0.105	0.422
0.021	0.031	---	---	---
---	---	---	---	---
0.127	---	0.095	0.071	0.143
---	---	---	---	---
---	---	---	---	0.068

Table 3. (Continued)

SPECIES	% frequency on Transect 1	11	12	13
Lactuca Serriola	04.5	---	---	---
Lepidium campestre	01.1	0.009	---	---
Lespedeza capitata	18.2	0.145	0.096	0.072
Liatris aspera	01.1	---	---	0.013
Liatris pycnostachya	03.4	---	---	---
Liatris squarrosa	11.4	0.022	0.060	---
Linum sulcatum	17.0	0.068	---	0.068
Lithospermum canescens	03.4	0.027	---	---
Monarda fistulosa	09.1	0.027	---	---
Muhlenbergia racemosa	02.3	0.018	0.036	---
Oenothera biennis	14.8	---	0.236	0.177
Oxalis europaea[a]	05.7	---	---	---
Panicum implicatum	27.3	0.072	0.109	0.109
Panicum leibergii	89.8	0.089	0.089	0.097
Parthenocissus quinquefolia	01.1	---	---	---
Petalostemum candidum[b]	30.7	0.245	0.245	0.046
Phlox pilosa	70.5	0.140	0.125	0.084
Physalis virginiana	03.4	---	---	---
Poa compressa	43.2	0.345	6.343	0.518
Poa pratensis	33.0	0.065	0.087	7.988
Polygonum scandens	03.4	---	---	---
Potentilla norvegica	22.7	---	0.060	0.136
Prunus americana	06.8	---	---	---
Ratibida pinnata	27.3	---	0.218	0.327
Rosa suffulta[c]	04.5	0.036	0.072	0.027
Salix humilis	06.8	1.100	0.108	---
Silphium integrifolium	46.6	0.074	0.149	0.186
Silphium laciniatum	09.1	---	---	0.036
Solidago canadensis	20.5	---	0.081	0.122
Solidago rigida	01.1	---	0.018	---
Sorghastrum nutans	01.1	---	---	---
Spartina pectinata	01.1	---	---	---
Sporobolus heterolepis	54.5	14.617	0.079	0.109
Stipa spartea	84.1	38.539	67.371	18.440
Urtica dioica	01.1	---	---	---
Viola pedatifida	25.0	---	0.036	0.060
Viola pedata	23.9	---	0.034	0.057
Zizia aurea	67.0	0.107	9.848	0.114

[a]Includes individuals of Oxalis stricta.

[b]Includes individuals of Petalostemum purpureum.

[c]A convenient taxonomic label for this often hybridizing group.

14	15	16	17	18
0.072	---	---	---	0.018
---	---	---	---	---
0.290	---	0.072	0.043	0.218
---	---	---	---	---
0.054	0.013	---	0.040	---
0.060	---	---	---	---
0.136	0.068	0.068	0.068	0.041
---	0.013	---	0.040	---
---	---	---	0.054	1.836
---	---	---	---	---
0.078	---	0.118	0.044	0.059
0.090	---	0.045	0.034	0.068
0.062	---	0.109	0.065	---
0.089	0.089	0.102	0.097	0.179
---	---	---	---	0.013
0.070	---	0.081	0.073	0.368
0.093	0.375	0.093	0.084	0.105
---	---	---	0.040	0.020
0.076	0.172	0.086	0.103	0.086
0.087	---	---	0.131	0.079
---	---	---	---	0.013
0.090	---	0.090	0.090	0.090
---	---	---	---	0.013
---	0.036	0.031	0.054	0.065
---	---	---	---	---
---	---	---	---	---
0.082	---	0.062	0.093	16.055
0.145	0.018	---	0.109	---
0.081	---	0.081	0.081	0.081
---	---	---	---	---
---	---	---	---	0.013
---	---	---	---	0.013
14.617	5.508	17.540	0.327	0.327
67.371	8.493	33.720	25.356	0.126
---	---	---	---	0.013
0.080	0.100	---	---	---
0.190	0.047	---	0.286	---
0.107	0.089	0.089	0.100	0.089

Twenty-three of the 84 species present on the prairie, but not sampled, could be placed into one of three categories, namely: adventive (8 species); woody plants (8 species); early spring plants (7 species). The early spring group consisted of species which mature early; consequently they were missed during the mid-summer and early fall sampling. The woody plant group was more or less restricted to the drainage ways. The adventive group was found mostly in areas of local disturbance (erosion sites, animal mounds and a former haystack site).

Adventive group	Woody group	Early Spring group
Achnida tamariscina	Corylus americana	Agoseris glauca
Amaranthus retroflexus	Fraxinus americana	Astragalus crassicarpus
Cannabis sativa	Populus deltoides	Delphinium virescens
Convolvulus sepium	Prunus serotina	Hypoxis hirsuta
Euphorbia maculata	Prunus virginiana	Pedicularis canadensis
Lepidium virginicum	Salix nigra	Senecio obovatus
Polygonum pensylvanicum	Ulmus pumila	Sisyrinchium campestre
Rumex crispus	Vitis riparia	

The deliniation of stands along both transects relative to slope position, altitude, and parent material is shown in Table 4. Certain parent materials were divided due to aspect or altitude change and were considered as discrete stands on this basis. Tables 5 and 6 show percent dominance and percent frequency for cover dominants in each of 10 stands on transect 2 and 8 stands on transect 1, respectively. In this instance, stands 8 and 10 were both split on the basis of a discrete altitude change. Sixteen species occurred as dominants on transect 2, and 15 species were dominants on transect 1.

Productivity data obtained from the clipped plots along both transects are given in Tables 7 and 8 including a value for the average oven-dry weight (g/m^2) in each stand. Twelve species occurred as mass dominants on transect 2 (stands 1-10) and 8 species were dominants on transect 1

Table 4. Deliniation of stands along 2 transects relative to slope position, altitude factors, and parent material, including the number of m^2 samples per stand

Stand	Slope Position[a]	Altitude Range (ft.)	Altitude Midpoint (ft.)	Altitude change per 10 m (ft.)	Parent Material	number of m^2 plots
1	2(0-10)	80.0-78.4	79.2	-1.60	loess	4
2	2(10-30)	78.4-71.4	74.9	-3.50	late Sangamon paleosol	8
3	2(30-60)	71.4-58.3	64.8	-4.36	late Sangamon paleosol B_3	12
4	2(60-70)	58.3-52.7	55.5	-5.60	Kansan till	4
5	2(70-90)	52.7-45.9	49.3	-3.40	till-derived sediment over till	8
6	2(90-110)	45.9-41.8	43.8	-2.05	alluvium	4
7	2(110-130)	41.8-39.4	40.6	-1.20	till-derived sediment over till	12
8	2(130-180)	39.4-34.8	37.1	-0.92	alluvium	32
	2(180-210)	34.8-44.5	39.6	+3.23		
9	2(210-240)	44.5-60.1	52.3	+5.20	till-derived sediment over till	12
10	2(240-260)	60.1-61.3	60.7	+0.60	Kansan till	16
	2(260-280)	61.3-56.5	58.9	-2.40		
11	1(0-20)	80.0-74.8	77.4	-2.60	loess	8
12	1(20-60)	74.8-64.2	69.5	-2.65	late Sangamon paleosol	16
13	1(60-90)	64.2-54.0	59.1	-3.40	late Sangamon paleosol B_3	12
14	1(90-130)	54.0-38.4	46.2	-3.90	Kansan till	16
15	1(130-140)	38.4-33.3	35.8	-5.10	Aftonian paleosol	4
16	1(140-160)	33.3-25.2	29.2	-4.05	Nebraskan till	8
17	1(160-190)	25.2-15.5	20.3	-3.23	till-derived sediment over till	12
18	1(190-220)	15.5-11.1	13.8	-1.46	alluvium	12
	1(220-230)	11.1-10.0	10.5	-1.10	alluvium	

[a]Distance in meters from the common origin with the number outside the brackets designating whether the stand occurs in transect 1 or in transect 2.

Table 5. Percent dominance (top figure) and percent frequency (bottom figure) for cover dominants in 10 stands relative to the mid-point of stand altitude (numbers in parentheses) on transect 2

SPECIES	1 (79.2)	2 (74.9)	3 (64.8)	4 (55.5)	5 (49.3)	6 (43.8)	7 (40.6)	8a (37.1)	8b (39.6)	9 (52.3)	10a (60.7)	10b (58.9)
Amorpha	---	---	---	---	---	---	---	---	---	---	---	14.3
canescens	50.0	87.5	25.0	25.0	12.5	---	---	20.0	25.0	33.3	75.0	87.5
Andropogon	---	---	---	---	---	100.0	50.0	25.0	---	---	---	25.0
Gerardii	---	12.5	08.3	---	---	25.0	33.3	20.0	---	41.6	62.5	50.0
Andropogon	---	---	33.3	66.6	85.7	100.0	55.5	41.6	---	---	---	50.0
scoparius	100.0	75.0	75.0	75.0	87.5	50.0	75.0	60.0	25.0	33.3	75.0	50.0
Aster	---	---	---	---	---	---	---	---	16.6	---	---	---
ericoides	---	---	16.6	---	---	---	25.0	40.0	50.0	25.0	41.6	---
Baptisia	---	---	---	---	---	---	---	---	---	---	---	100.0
leucophaea	---	12.5	---	---	---	---	---	---	---	---	---	12.5
Ceanothus	100.0	100.0	57.1	---	---	---	---	---	---	---	33.3	20.0
ovatus	25.0	12.5	58.3	50.0	25.0	---	---	---	---	41.6	75.0	62.5
Elymus	---	---	---	---	---	---	---	18.1	---	---	---	---
canadensis	25.0	---	33.3	50.0	62.5	50.0	41.6	55.0	25.0	41.6	50.5	12.5
Elymus	---	---	---	---	---	---	---	25.0	---	---	---	---
virginicus	---	---	---	---	---	---	---	20.0	---	---	---	12.5
Poa	---	---	---	---	---	---	---	---	10.0	---	---	---
compressa	---	---	---	---	---	---	08.3	20.0	83.3	66.6	25.0	25.0
Poa	---	---	---	---	---	---	28.5	---	---	25.0	---	---
pratensis	25.0	---	16.6	50.0	12.5	25.0	58.3	05.0	25.0	33.0	---	---
Rhus	---	---	100.0	100.0	---	---	---	---	---	---	---	---
radicans	---	---	16.6	25.0	12.5	25.0	---	---	---	---	---	---
Salix	---	14.3	---	---	---	---	---	---	---	---	---	---
humilis	75.0	87.5	08.3	---	---	---	---	---	---	---	---	---
Silphium	---	---	---	---	---	---	---	12.5	---	---	---	---
integrifolium	25.0	62.5	25.0	---	25.0	---	58.3	80.0	25.0	25.0	---	25.0
Sorghastrum	---	---	---	---	---	---	---	---	14.3	60.0	20.0	28.5
nutans	---	12.5	16.6	---	---	50.0	33.3	10.0	58.3	41.6	62.5	87.5
Sporobolus	100.0	57.1	---	50.0	33.3	---	40.0	33.3	100.0	50.0	---	20.0
hetrolepis	100.0	87.5	50.0	50.0	37.5	50.0	41.6	15.0	08.3	33.3	12.5	62.5
Stipa	---	75.0	58.3	---	28.5	33.3	30.0	47.0	83.3	58.3	100.0	12.5
spartea	100.0	100.0	100.0	75.0	87.5	75.0	83.3	85.0	100.0	100.0	100.0	100.0

Table 6. Percent dominance (top figure) and percent frequency (bottom figure) for cover dominants in 8 stands relative to mid-point of stand altitude (numbers in parentheses) on transect 1

SPECIES	11 (77.4)	12 (69.5)	13 (59.1)	14 (46.2)	15 (35.8)	16 (29.2)	17 (20.3)	18 (13.8)
Ambrosia	---	---	---	---	---	---	---	100.0
trifida	---	---	---	---	---	---	---	16.6
Amorpha	---	33.3	---	---	---	14.3	11.1	---
canescens	87.5	93.7	91.6	100.0	100.0	87.5	75.0	16.6
Andropogon	42.8	---	42.8	---	---	---	70.0	87.5
Gerardii	87.5	25.0	58.3	37.5	---	12.5	83.3	66.6
Andropogon	---	35.7	57.1	72.7	33.3	50.0	14.3	100.0
scoparius	62.5	87.5	58.3	68.7	75.0	100.0	58.3	08.3
Aster	---	50.0	---	---	---	---	---	---
ericoides	---	12.5	08.3	06.2	---	25.0	33.3	33.3
Ceanothus	33.3	40.0	50.0	20.0	---	---	---	---
ovatus	37.5	31.2	66.6	31.2	---	12.5	---	---
Elymus	---	---	---	---	---	---	---	20.0
virginicus	---	---	---	---	---	---	08.3	41.6
Monarda	---	---	---	---	---	---	---	16.6
fistulosa	---	---	---	---	---	---	16.6	50.0
Poa	---	10.0	---	---	---	---	---	---
compressa	12.5	68.7	08.3	56.2	25.0	50.0	41.6	50.0
Poa	---	---	20.0	---	---	---	---	---
pratensis	50.0	37.5	41.6	37.5	---	---	25.0	41.6
Salix	20.0	---	---	---	---	---	---	---
humilis	62.5	06.2	---	---	---	---	---	---
Silphium	---	---	---	---	---	---	---	28.5
integrifolium	62.5	31.2	25.0	56.2	---	75.0	50.0	58.3
Sporobolus	33.3	---	---	16.6	25.0	40.0	---	---
heterolepis	75.0	68.7	50.0	75.0	100.0	62.5	16.6	16.6
Stipa	57.1	50.0	18.1	16.6	25.0	50.0	25.0	---
spartea	87.5	87.5	91.6	87.5	100.0	100.0	66.6	66.6
Zizia	---	09.1	---	---	---	---	---	---
aurea	62.5	68.7	58.3	62.5	75.0	75.0	66.6	75.0

Table 7. Mass dominants and biomass of standing crop and litter in 10 stands on transect 2 in g oven-dry material/m^2

		STANDING			LITTER[a]	
Stand	Clipping date	Mass dominant	Oven-dry wt.	Ave. dry wt./stand	Oven-dry wt.	Ave. dry-wt./stand
1	10/19/68	Sporobolus heterolepis	505.0	505.0	240.0	240.0
2		Sporobolus heterolepis	615.0	655.0	340.0	375.0
		Salix humilis	695.0		410.0	
3		Ceanothus ovatus	475.0	475.0	300.0	270.0
		Stipa spartea	660.0		425.0	
		Stipa spartea	290.0		85.0	
4		Stipa spartea	470.0	470.0	125.0	125.0
5		Andropogon scoparius	380.0	455.0	80.0	72.0
		Andropogon scoparius	530.0		65.0	
6		Andropogon Gerardii	390.0	340.0	685.0	825.0
		Andropogon scoparius	290.0		965.0	
7		Sporobolus heterolepis	330.0	445.0	170.0	135.0
		Andropogon scoparius	560.0		100.0	
8	10/6/68	Elymus canadensis	495.0	607.0	270.0	328.0
		Andropogon Gerardii	1475.0		245.0	
		Stipa spartea	315.0		325.0	
		Sporobolus heterolepis	520.0		535.0	
		Muhlenbergia racemosa	295.0		680.0	
		Vernonia Baldwini				
		Stipa spartea	610.0		175.0	
		Andropogon Gerardii	720.0		255.0	
		Poa pratensis	430.0		135.0	
9		Silphium integrifolium	425.0	375.0	30.0	191.0
		Sporobolus heterolepis	345.0		50.0	
	9/21/68	Andropogon scoparius	355.0		495.0	
10		Sorghastrum nutans	275.0	288.0	300.0	392.0
		Sporobolus heterolepis	115.0		355.0	
		Sporobolus heterolepis	505.0		550.0	
		Sporobolus heterolepis	250.0		365.0	

[a]Litter was not recognizable to the point of a dominance determination by species.

Table 8. Mass dominants and biomass of standing crop and litter in 8 stands on transect 1 in g oven-dry material/m^2

Stand	Clipping date	STANDING Mass dominant	Oven-dry wt.	Ave. dry wt./ stand	LITTER[a] Oven-dry wt.	Ave. dry wt./ stand
11	8/23/68	Amorpha canescens	615.0	540.0		285.0
		Stipa spartea	465.0		285.0	
12	8/27/68	Sporobolus heterolepis	415.0	438.0	395.0	451.0
		Sporobolus heterolepis	520.0		680.0	
		Stipa spartea	430.0		455.0	
		Andropogon scoparius	375.0		275.0	
13		Ceanothus ovatus	585.0	435.0	710.0	528.0
		Stipa spartea	285.0		345.0	
14		Andropogon scoparius	190.0	267.0	125.0	185.0
		Stipa spartea	310.0		185.0	
		Andropogon scoparius	230.0		180.0	
	9/3/68	Sorghastrum nutans	245.0		240.0	
		Sporobolus heterolepis				
		Eryngium yuccifolium	360.0		195.0	
15		Sporobolus heterolepis	430.0	430.0	195.0	195.0
16	9/4/68	Sporobolus heterolepis	450.0	390.0	190.0	190.0
		Sporobolus heterolepis	330.0		190.0	
17		Andropogon Gerardii	750.0	502.0	185.0	178.0
		Sporobolus heterolepis	480.0		125.0	
		Andropogon Gerardii	275.0		225.0	
18		Stipa spartea	270.0	444.0	210.0	296.0
		Stipa spartea	445.0		375.0	
		Stipa spartea	490.0		360.0	
		Sporobolus heterolepis	570.0		240.0	

[a]Litter was not recognizable to the point of a dominance determination by species.

(stands 11-18). Mass dominants common to both transects were Andropogon Gerardii, Andropogon scoparius, Ceanothus ovatus, Sorghastrum nutans, Sporobolus heterolepis, and Stipa spartea. Stands 3 and 13 are similar in having the same late Sangamon parent material, the same mass dominants (Ceanothus ovatus and Stipa spartea), the same slope position relative to the in situ progression of parent materials, and a distinct overlap in altitude ranges.

Continuum-index values for six parent materials are shown in Table 9. Stands with similar parent materials were grouped to facilitate placement on an assumed moisture gradient, based on the frequency of indicator species in these grouped stands. Continuum values ranged from 340.9 (loess) to 303.2 (alluvium). Tables 10 and 11 show the continuum-index values and frequencies of indicator species for each stand in transect 2 and 1, respectively. Stands on transect 2 ranged from 347.3 (stand 5) to 305.2 (stand 4) and on transect 1 from 340.0 (stand 11) to 265.5 (stand 18).

Stand productivity in terms of average dry weight of standing and litter material is compared with the stand continuum index in Figures 5, 6, 7, and 8. In Figures 7 and 8, stands are arranged from left to right in order of decreasing (dry to wet) continuum index while in Figures 5 and 6, stands are arranged as they actually appear on the slope. It can be seen from the graphs that implied soil moisture (continuum index) varies with parent material and does increase downslope if only the extremes are considered. A few relationships between continuum index and productivity will be discussed in the next chapter.

As a further attempt to characterize stands, species importance values were calculated and are presented in Tables 2 and 3. The most important

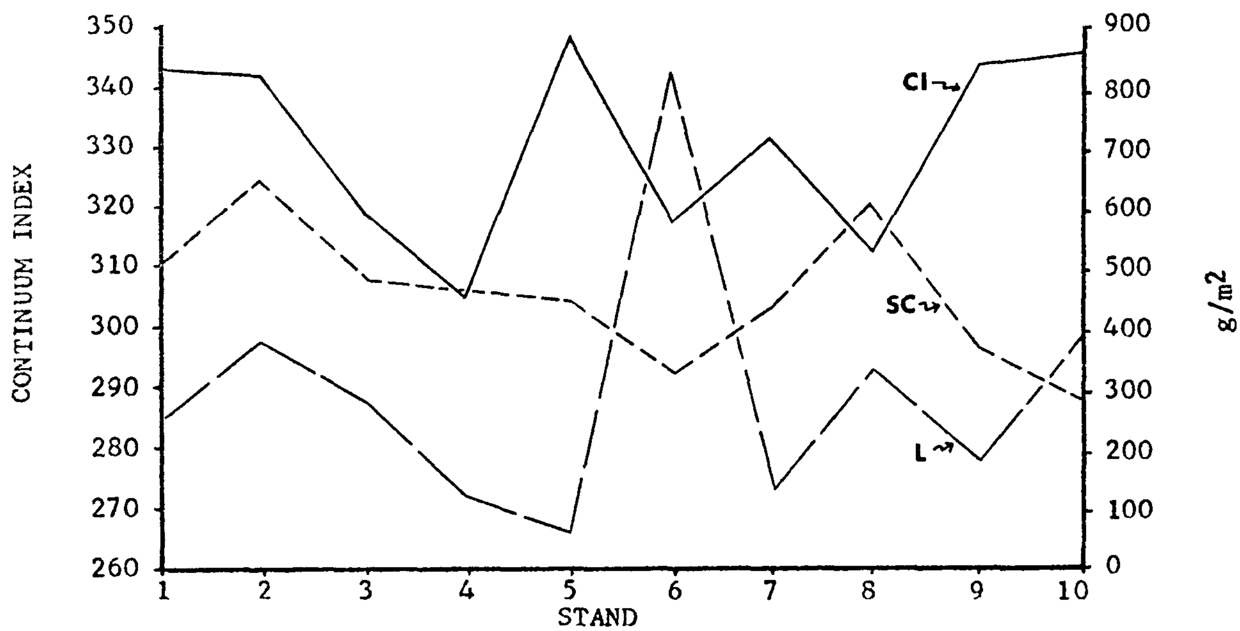

Figure 5. Biomass of standing crop (SC) and litter (L) relative to slope position and continuum index (CI) for 10 stands in transect 2

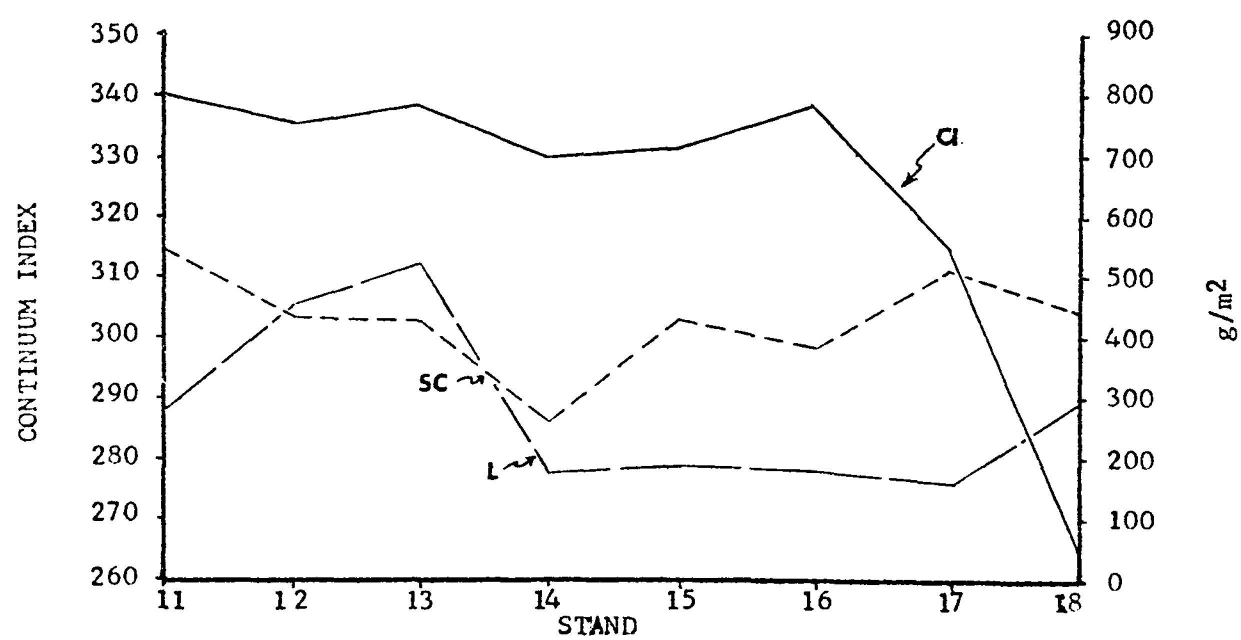

Figure 6. Biomass of standing crop (SC) and litter (L) relative to slope position and continuum index (CI) for 8 stands in transect 2

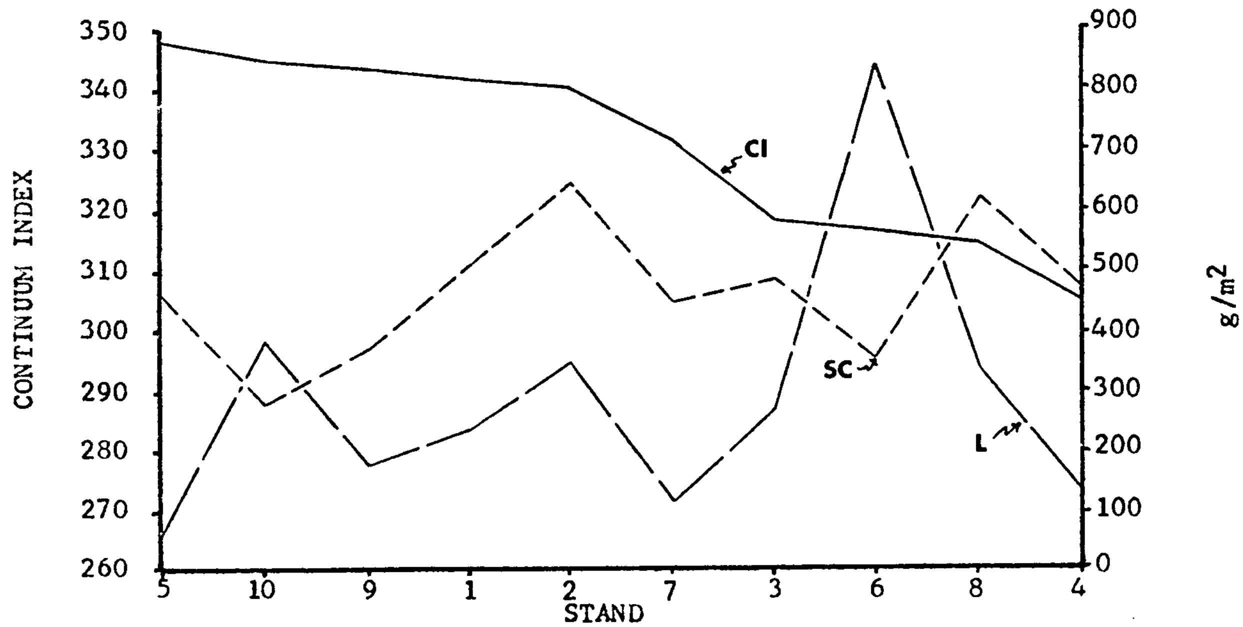

Figure 7. Biomass of standing crop (SC) and litter (L) relative to slope position with stands arranged from left to right in order of decreasing continuum index (CI) on transect 2

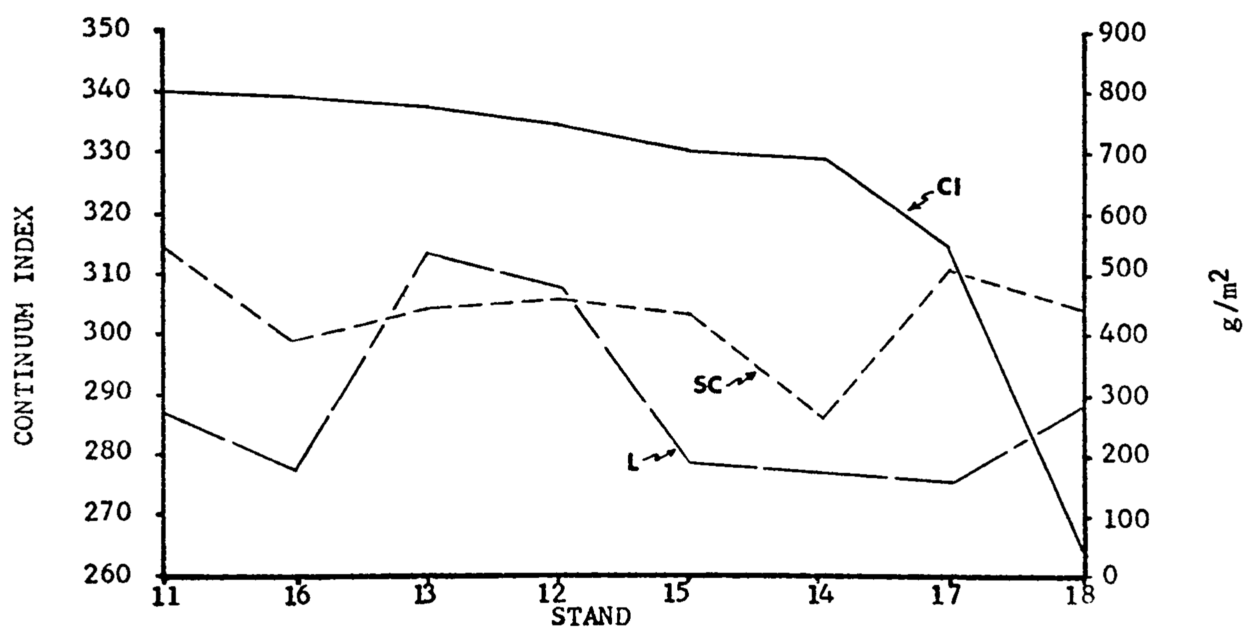

Figure 8. Biomass of standing crop (SC) and litter (L) relative to slope position with stands arranged from left to right in order of decreasing continuum index (CI) on transect 1

Table 9. Frequency values for continuum indicator species relative to combined parent material units arranged from left to right in order of decreasing continuum index number for the parent material units

Indicator species	Loess (1,11)[a]	Till (4,10,14,16)	Late Sangamon paleosol (2,3,12,13)	Aftonian paleosol (15)	Till-derived sediment over till (5,7,9,17)	Alluvium (6,8,18)
Wet						
Spartina pectinata	---	---	---	---	---	.019
Zizia aurea	.583	.591	.688	.750	.477	.596
Wet-mesic						
Fragaria virginiana	.083	.045	.042	---	.091	.135
Helianthus grosseserratus	---	---	---	---	---	.019
Phlox pilosa	.583	.795	.604	.750	.545	.423
Mesic						
Aster laevis	---	.454	.104	1.000	.159	.096
Desmodium illinoense	---	.023	.063	---	.045	.038
Eryngium yuccifolium	.166	.068	.021	.500	.136	.058
Liatris aspera	---	---	.042	---	---	---
Panicum leibergii	1.000	.932	.961	1.000	.818	.692
Ratibida pinnata	---	.295	.166	.750	.568	.442
Solidago missouriensis	---	---	---	---	---	.058
Dry-mesic						
Linum sulcatum	.250	.159	.104	.250	.159	.019
Petalostemum candidum	.083	.341	.250	---	.159	.269
Sporobolus heterolepis	.833	.568	.729	1.000	.318	.154
Stipa spartea	.916	.931	.833	1.000	.841	.769
Dry						
Andropogon scoparius	.750	.727	.750	.750	.614	.346
Aster sericeus	.250	.272	.187	---	---	---
Bouteloua curtipendula	---	.159	.021	.500	.205	.019
continuum index$_{(f)}$	340.9	334.4	332.8	330.3	329.7	303.2

[a]Figures in brackets represent the stands having similar parent materials.

Table 10. Frequencies of indicator species in 10 stands and the continuum index values for the same 10 stands along transect 2

Indicator species	1 (342.3)[a]	2 (341.4)	3 (319.4)	4 (305.2)	5 (347.3)	6 (317.6)	7 (333.8)	8 314.3)	9 (344.4)	10 (345.9)
Wet										
Zizia aurea	.500	.500	.916	1.000	.500	.500	.750	.626	---	.375
Wet-mesic										
Fragaria virginiana	.250	.125	---	---	.250	---	.083	.125	---	---
Helianthus grosseserratus	---	---	---	---	---	.250	---	---	---	---
Phlox pilosa	.750	.375	.583	.500	.250	.250	.416	.406	.583	.937
Mesic										
Aster laevis	---	.125	.250	.500	.375	---	.166	.094	.083	.250
Desmodium illinoense	---	---	---	---	---	---	.083	.063	.083	.062
Eryngium yuccifolium	.500	---	.083	---	---	.250	.250	.063	---	---
Liatris aspera	---	.125	---	---	---	---	---	---	---	---
Panicum leibergii	1.00	.875	.833	.750	.625	.750	.667	.843	1.000	.937
Ratibida pinnata	---	.125	.333	---	.250	.500	.667	.500	.750	.375
Solidago missouriensis	---	---	---	---	---	---	---	.094	---	---
Dry-mesic										
Linum sulcatum	.250	.250	---	---	---	---	.166	.031	---	.187
Petalostemum candidum	---	---	.166	---	---	---	.083	.406	.083	.312
Sporobolus heterolepis	1.000	.875	.500	.500	.375	.500	.416	.125	.333	.375
Stipa spartea	1.000	1.000	1.000	.750	.875	.750	.833	.906	1.000	1.000
Dry										
Andropogon scoparius	1.000	.750	.750	.750	.875	.500	.750	.468	.333	.625
Aster sericeus	.250	---	.166	---	---	---	---	---	---	.500
Bouteloua curtipendula	---	---	---	---	.375	---	.083	.031	.250	.187

[a] The figure in brackets indicates the continuum-index$_{(f)}$ for each stand.

Table 11. Frequencies of indicator species in 8 stands and the continuum index values for the same 8 stands along transect 1

Indicator species	11 (340.0)[a]	12 (334.9)	13 (337.8)	14 (329.9)	15 (330.8)	16 (339.6)	17 (315.9)	18 (265.5)
<u>Wet</u>								
Spartina pectinata	---	---	---	---	---	---	---	.062
Zizia aurea	.625	.687	.583	.625	.750	.750	.667	.562
<u>Wet-mesic</u>								
Fragaria virginiana	---	.062	---	.062	---	.125	.083	.187
Phlox pilosa	.500	.562	.833	.750	.750	.750	.833	.500
<u>Mesic</u>								
Aster laevis	---	---	.083	.562	1.000	.625	.083	.125
Desmodium illinoense	---	---	.250	---	---	---	---	---
Eryngium yuccifolium	---	---	---	.187	.500	---	.250	---
Liatris aspera	---	---	.083	---	---	---	---	---
Panicum leibergii	1.000	1.000	.916	1.000	1.000	.875	.916	.375
Ratibida pinnata	---	.125	.083	---	.750	.875	.500	.312
<u>Dry-mesic</u>								
Linum sulcatum	.250	---	.250	.125	.250	.250	.416	---
Petalostemum candidum	.125	.125	.667	.438	---	.375	.416	.062
Sporobolus heterolepis	.750	.687	.916	.750	1.000	.625	.166	.125
Stipa spartea	.875	.875	.500	.875	1.000	1.000	.667	.500
<u>Dry</u>								
Andropogon scoparius	.625	.875	.583	.687	.750	1.000	.583	.062
Aster sericeus	.250	.125	.416	.187	---	.125	---	---
Bouteloua curtipendula	---	.062	---	---	.500	.500	.166	---

[a]The figure in brackets indicates the continuum-index$_{(f)}$ for each stand.

species occurring in any stand as dominants were Stipa spartea (184.547), Andropogon scoparius (77.158), Sporobolus heterolepis (61.732), Andropogon Gerardii (51.381), and Amorpha canescens (43.119) while important non-dominants were Helianthus grosseserratus (0.003), Liatris aspera (0.007), and Polygonum scandens (0.007). All were most important in stands with an alluvial parent material except Liatris aspera which occurred on a late Sangamon paleosol. Important species in each of the 18 stands are shown in Tables 12 and 13. Species were listed only if the value was $>$ 10.000 or $<$ 0.030 on the importance continuum.

Data from the Orloci (1966) ordination of species are presented in Tables 15 and 16 (Appendix) including coordinates for X, Y, and Z axes. Ordination on the X-axis was by percent frequency for species, using locations as axes. The two most different species on transect 1 were Panicum leibergii and Elymus virginicus while on transect 2 they were Stipa spartea and Potentilla norvegica. The remaining 54 species formed more or less distinct groups between the extremes on both transects. The basis for ordination on the Y and Z axes was not assignable.

Table 12. Important species for stands based on the occurrence of the highest importance value for that species relative to all stands on transect 2

Stand 1
- Helianthemum Bicknellii
- Liatris squarrosa
- Salix humilis
- Eryngium yuccifolium

Stand 2
- Ceanothus ovatus
- Liatris aspera
- Solidago rigida
- Baptisia leucophaea
- Antennaria plantaginifolia

Stand 3
- Prunus americana
- Heliopsis helianthoides

Stand 4
- Aster simplex
- Lactuca Serriola
- Cirsium altissimum

Stand 5
- Polygonum scandens
- Silphium laciniatum
- Bouteloua curtipendula
- Artemisia ludoviciana

Stand 6
- Helianthus grosseserratus
- Muhlenbergia racemosa
- Kuhnia eupatorioides
- Rhus radicans
- Vernonia Baldwini

Stand 7
- Onosmodium occidentale

Stand 8
- Stipa spartea
- Andropogon scoparius
- Sporobolus heterolepis
- Andropogon Gerardii
- Elymus canadensis
- Silphium integrifolium
- Lepidium campestre
- Liatris pycnostachya
- Melilotus officinalis
- Phleum pratense
- Physalis virginiana
- Potentilla canadensis
- Solidago missouriensis

Stand 9
- Sorghastrum nutans
- Setaria Lutescens
- Oxalis europaea
- Erigeron strigosus
- Onosmodium occidentale

Stand 10
- Ulmus rubra
- Aster sericeus
- Hieracium longipilum
- Panicum virgatum
- Panicum implicatum
- Ambrosia artemisiifolia
- Lithospermum canescens
- Potentilla norvegica
- Viola pedatifida

Table 13. Important species for stands based on the occurrence of the highest importance value for that species relative to all stands on transect 1

Stand 11
- Comandra umbellata
- Juniperus virginiana
- Lepidium compestre
- Baptisia leucphaea
- Bromus Tectorum
- Muhlenbergia racemosa
- Helianthemum Bicknellii
- Liatris squarrosa

Stand 12
- Stipa spartea
- Amorpha canescens
- Ceanothus ovatus
- Aster ericoides
- Solidago rigida

Stand 13
- Desmodium illinoense
- Kuhnia eupatorioides
- Liatris aspera
- Lactuca biennis
- Rosa suffulta

Stand 14
- Stipa spartea
- Hordeum Jubatum

Stand 15
- Liatris pycnostachya
- Lithospermum canescens
- Eryngium yuccifolium
- Silphium laciniatum
- Bouteloua curtipendula
- Aster laevis
- Carex sp.

Stand 16
- Sporobolus heterolepis
- Baptisia leucantha
- Gentiana puberula
- Bouteloua curtipendula

Stand 17
- Achillea Millifolium
- Ambrosia artemisiifolia

Stand 18
- Andropogon scoparius
- Andropogon Gerardii
- Silphium integrifolium
- Acer Negundo
- Aster simplex
- Cornus stolonifera
- Geum canadense
- Parthenocissus quinquefolia
- Polygonum scandens
- Prunus americana
- Sorghastrum nutans
- Spartina pectinata
- Urtica dioica
- Lactuca Serriola
- Achillea Millefolium
- Heliopsis helianthoides
- Physalis virginiana

DISCUSSION AND CONCLUSIONS

Sheeder Prairie is best described as a tall-grass dominanted, mesic, upland prairie. Tall-grass species, encountered as dominants in sample plots, comprised 31.6% of the total number of species occurring as dominants. Two low-growing woody species (Ceanothus ovatus and Salix humilis) occurred exclusively in upland stands. Andropogon scoparius, Sporobolus heterolepis, and Stipa spartea were the only tall-grass species to occur in every stand, and at least one of these species was a dominant in every stand. Although Andropogon Gerardii is present in low to middle frequencies in several stands, its highest frequency and percentage dominance occurred in stands of lower slopes and drainage ways (stands 6, 7, 8, 17, 18). Sorghastrum nutans, on the basis of frequency and occurrence, is notably absent from transect 1 (except stand 18) yet present in middle to high frequencies on transect 2. This was due entirely to non-recognition of the species, vegetatively, during the early part of the study when transect 1 was sampled. Later random checking showed that Sorghastrum nutans was abundant along transect 1.

Upland prairies have been characterized in Wisconsin by Curtis and Green (1949), and in Iowa by Moyer (1953). The number of species ranged from 130 to 180 with Compositae, Gramineae and Fabaceae being the principal families in upland areas. The data in Table 1 show that Sheeder Prairie does fit within these limits and therefore can be correctly termed an upland prairie. Curtis and Green (1949) also listed preferential species (based on presence data) for upland areas. Wisconsin prairies have about a 70% correlation with Iowan prairies on species presence basis. Although a number of the Curtis lowland species are present, only four are of any consequence relative to moderately high frequency and occurrence as dominants.

Characterization of Sheeder Prairie as a mesic area is supported by the range of continuum-index values for the 18 stands. Stands ranged from 347.3 (dry-mesic) to 265.5 (wet-mesic) using the continuum index based on frequency which tends to favor indicator species of high frequency such as Andropogon scoparius (dry indicator); Sporobolus heterolepis and Stipa spartea (dry-mesic indicators); Panicum leibergii (mesic indicator); Phlox pilosa (wet-mesic indicator) and Zizia aurea (wet indicator). With the exception of stand 18 (at 265.5) all other stands fell between 305.2 and 347.3 on the continuum. The continuum index (frequency based) for the prairie, calculated by grouping all 18 stands, is 327.4 (mesic).

Of the 19 species which are prairie dominants eight are most characteristic of the upland areas (stands 1-4, 10-16) principally Sharpsburg, Shelby and Adair soil types. These species are Amorpha canescens, Andropogon scoparius, Baptisia leucophea, Ceanothus ovatus, Salix humilis, Sorghastrum nutans, Sporobolus heterolepis, and Stipa spartea. The remaining stands (5-9, 17-18) have alluvial or till-derived sediments as the parent material. Rhus radicans seems to be of local importance in these stands as it occurs in areas of recent alluviation in small drainage ways. Species with broad ecological amplitudes are difficult to relate to site characters regardless of whether they are dominants or non-dominants. Species in this category include Poa pratensis, Panicum leibergii, Phlox pilosa, Zizia aurea, Euphorbia corollata, Echinacea pallida, and Ratibida pinnata. These species occurred at moderate to high frequencies and were present in most stands. If these species have indicator value (using (presence) it is certainly not on an intra-stand basis. Several species were more or less restricted to the narrow drainage ways or the broad alluvial areas (Figure 2). Drainage-way species included Acer Negundo, Prunus americana, Salix nigra, Fraxinus americana, Populus deltoides, Sambucus canadensis, Rhus radicans, Sanicula marilandica, Campanula americana, Solidago missouriensis, Veronicastrum virginicum, Galium Aparine, Galium boreale, Ambrosia trifida, Monarda fistulosa and Urtica dioica. Local disturbances within the broad alluvial area precipitated the appearance of Cannabis sativa, Elymus virginicus, Amaranthus retroflexus, Acnida tamariscina, Chenopodium album and Conyza canadensis on the site of a former haystack. Species found in the alluvial area, but not sampled were Prunella vulgaris, Lactuca canadensis, Senecio obovatus, Convolvulus sepium, Rumex crispus, Agrostis alba, Leersia virginica, Polytaenia Nuttallii, and Polygonum pensylvanicum.

Use of the prairie continuum index (Curtis, 1955) was justified on the basis of three criteria related to the Wisconsin work. To be classed as a discrete stand, an area had to contain a minimum of 20 species, including five of the continuum indicator species, and no less than four m^2 samples. This appears highly modified in view of the Wisconsin work which permitted a minimum of 30 species including five indicators and always used 20 m^2 samples per stand. The modification of the prairie continuum to use frequency served to compensate for the variability in the number of samples per stand as well as the low number of indicators present. Ordination of small stands within a discrete vegetative unit such as Sheeder Prairie would prove difficult unless allowances were made for species distribution within the unit. Use of the frequency based continuum accomplishes this by giving species with high frequency more weight in the continuum calculation.

A modification or at least a re-evaluation of the Curtis indicator species for our range seems warranted in view of values reported herein and from recent Iowa literature (Freckman, 1966).

Continuum values for combined parent materials (Table 9) place these general units on the moisture gradient from dry to wet as follows: loess, till, Sangamon paleosol, Aftonian paleosol, till-derived sediment over till, and alluvium. When stands are considered in transects or as individuals, this ordination does not hold due to differences in degree of slope, aspect and assumed moisture (as reflected by the continuum). These factors are enough to change both frequency and presence of indicators (Tables 10 and 11). Two specific stands (9 and 17) have parent material, number of m^2 samples and transect distance in common, but differ in aspect (stand 9, ESE and stand 17, WSW); number of indicator species (stand 9, has 10 and stand 17 has 13 indicators); continuum index (stand 9 is 344.4 and stand 17 is 315.9); frequency of indicator species (Tables 10 and 11); and degree of slope as seen in Table 4, (stand 9 drops at a rate of 5.20 feet per 10 meters and stand 17 at a rate of 3.23 feet per 10 meters). Generally a westerly aspect should be slightly drier than its easterly facing counterpart but due to the steeper slope in stand 9, it is the drier of the two sites. Other stands show similar trends indicating that applications of the prairie continuum to transect stands are complex and that values result from an interaction of several factors as expressed in the vegetation. A direct examination of soil moisture would have been invaluable at this point in lending confidence to the continuum values and the original stand delineations. A few refinements in technique and further modification of indicators should fit the prairie continuum for use in transect-stand studies of this type; as its basic tenant of continuous variability through stands fits both intra-stand (transect stands within Sheeder Prairie) and inter-stand (Sheeder Prairie vs. other prairie relicts) applications.

Several of the indicator species used in the continuum analysis have moderate to high frequencies in several stands. This adds further confusion in the assignment of species as characteristic of a stand relative to slope position. To compensate somewhat a species importance value was assigned to each species in each of the 18 stands (Table 2 and 3) while keeping the two transects relatively discrete to avoid the difficulties encountered in dealing with aspect. Even so, the characterization of stands proved to be tedious and difficult. The nature of the resulting continuum itself proved to be a major stumbling block as it ordinates dominant species on one side of a natural break and non-dominants on the other with both increasing in importance from the break toward the extremes. This results in separate handling of data sets and only a relative way of determining points of equal importance when considering a dominant versus a non-dominant. The dominance region of the continuum is 320.320 times as large as the non-dominant region. This means that a non-dominant species with an importance value of 0.001 is equivalent to a dominant species with an importance value of 320.000. Only one species in one stand approaches this upper value, with Stipa spartea (stand 8) having a value of 184.547. The most important species on the non-dominant scale is Helianthus grosseserratus (stand 6) with a value of 0.003 which would give its dominant equivalent a value of 318.720. The futility of this type of comparison becomes evident when importance values for dominants (Tables 2 and 3) show that with the exception of _Stipa spartea_ (stand 8) the range is about 1.000 to 84.000. The equivalent dominant value for the most unimportant non-dominant species (0.600) is 127.807 and most of the non-dominant values range from 0.003 to 0.300 which would relegate the dominants to an extremely insignificant role under this type of comparison. It was decided to interpret species importance rather subjectively by considering species with values > 10.000 and < 0.030 as very important. Tables 12 and 13 show the distribution of species according to the stand in which the species had its most important value within the described range, keeping the transects separated. Stands 1 and 11 are comparable in prairie continuum values (342.3 and 340.0, respectively) and have two species, _Liatris squarrosa_ and _Helianthemum Bicknellii_ in common, both of which are present only in upland stands and then as non-dominants on a loess or late Sangamon paleosol. Stands 2 and 12 also have two species in common, _Ceanothus ovatus_ and _Solidago rigida_. _Ceanothus ovatus_ occurs in upland stands, is often a dominant, and was also found in stand 9. Prairie continuum values for these three stands were very similar and had values of 334.9 (stand 12), 341.4 (stand 2), and 344.4 (stand 9). Stands 2 and 9 have a steeper slope probably accounting for the slightly drier continuum values. Stands 3 and 13 were mentioned in the results section as having several similarities. The overlap in altitude as well as slope position is not expressed in similar moisture regimes, as the continuum indexes are distinctly different (337.8 and 319.4) and are again an expression of slope degree. Individual stands, with the exception of the similarity comparisons above, are different enough to be discussed more or less individually with reference to Tables 12 and 13.

Two of the four important species in stand 1 were discussed above and a third, Salix humilis, is worthy of note. This species occurs in five stands (1, 2, 3, 11, 12) all of which are high upland stands. It is dominant in 11 and 2 and is colonial in nature, so that where it occurs it is important. Stand 1 has a loess parent material and is the fourth dryest stand based on a continuum index of 342.3. Ceanothus ovatus is also an important dominant in this stand.

Stand 2 has a continuum index of 342.4 which is comparable to stand 1 and is probably different due to the two-fold increase in slope degree and the outcropping of the late Sangamon paleosol. Important species, in addition to those in Table 12, are Helianthemum Bicknellii and Stipa spartea. Helianthemum Bicknellii occurs exclusively in the upland stands at low frequencies, indicating a limited distribution. Stipa spartea is a frequent dominant with regular distribution in this stand. Ceanothus ovatus was a dominant in every plot in which it occurred.

Stand 3 grades steeply toward a small drainage way and has a continuum index of 319.4. The relative wetness is probably inherent in the parent material which is the exposed B_3 horizon of a late Sangamon paleosol. Two woody species, Rhus radicans and Prunus americana are important on this site, although, Rhus radicans increases in importance downslope as it occurs as a dominant in this stand and the next. The presence of Heliopsis helianthoides seems to be a direct reflection of the moisture regime as most of its other occurrences are in the wetter stands. This stand contains 39 species, significantly more than stands 1, 2, and 4.

The continuum index for stand 4 is 305.2, the wetness best explained by its position on the slope below stand 3 from which it probably receives a high amount of runoff. Aster simplex, an important species here, occurs exclusively in the wettest stands as does Cirsium altissimum, for the most part. Rhus radicans, Sporobolus heterolepis, and Zizia aurea are important dominants in this stand.

Stand 5 reflects its dry continuum index (347.3) with the importance of Bouteloua curtipendula and Silphium laciniatum. This was the dryest stand sampled. Andropogon scoparius was important as it dominanted 85% of the plots in which it was present.

Stands 6, 8 and 18 are best characterized by a diversity of species. These alluvial stands all had wet continuum indexes being 317.6, 314.3 and 265.5 respectively, and generally contained a greater number of species than other stands. Several species not found on any other parent material occurred in these stands, if only infrequently, and are listed in Tables 12 and 13 along with the other important species.

Both stands 7 and 9 were relatively dry according to the continuum indexes which were 333.8 and 344.4, respectively. Onosmodium occidentale was found exclusively in these stands, though never dominant. Stand 7 occupied a position between two alluvial stands which is somewhat reflected by the continuum value. Stand 9 occupied a steep, much disturbed slope which accounts for its rather dry continuum index and the importance of several "weedy" species, namely Setaria lutescens, Ambrosia artemisiifolia, and Poa pratensis, a dominant.

Stand 10 had a continuum index of 345.9 and exhibited several upland species as important (Table 12). Ceanothus ovatus, Sorghastrum nutans, and

Stipa spartea were important dominants on this upland ridge.

Stands 11, 12, and 13 have already been discussed. Stands 14 and 15 had continuum indexes of 329.9 and 330.3, respectively. Andropogon scoparius, Ceanothus ovatus and Sporobolus heterolepis were relatively important as dominants in stand 14 while Hordeum Jubatum was an important non-dominant in both of the stands and was not present in any of the other stands. The degree of slope changes strongly through these stands which corresponds with the appearance of the Aftonian paleosol. A decrease in overall height of the vegetation in stands 14 and 15 is obvious.

Stand 16 lies on Nebraskan till and is the second dryest stand on this slope based on a continuum index of 339.6. Amorpha canescens, Andropogon scoparius and Stipa spartea are important dominants not listed in Table 12. This was the only stand in which Baptisia leucantha occurred.

Stand 17 was relatively wet with till-derived sediment overlying Nebraskan till for a parent material. Achillea Millifolium was present in this and in stand 18 only. Amorpha canescens and Andropogon Gerardii were important dominants not listed in Table 13.

The application of species importance values to the characterization of stands on a continuously varying gradient proved to be hazardously subjective. A simplification of the index is needed to eliminate the inconsistencies caused by any change in species frequency or dominance and to facilitate comparison of relative importance values for dominants versus non-dominants.

Raw data on biomass of standing crop and litter material including mass dominants are presented in Tables 7 and 8. Fourteen species make up the list of mass dominants and include eight grasses, three forbs and three woody shrubs. The woody species were dominant only in the upper three stands of each transect relative to slope position. Stands with the highest average oven-dry weight of standing material were stand 2 with 655 g/m^2 and stand 8 with 607 g/m^2. Stand 6 had an average oven-dry weight of 825 g/m^2 for litter material with Andropogon Gerardii and A. scoparius as dominants. Stand 8 had the widest range, with values for standing material ranging from 295 g to 1475 g/m^2 and from 135 g to 680 g/m^2 for litter material.

Graphic presentation of production averages by stand relative to the stand continuum index and slope position are shown in Figures 5 and 6. With the exception of stands 6, 10, 12 and 13; the amount of standing plant material was proportionally greater than the amount of litter material. The tremendous quantity of litter in stand 6 may have been due to the growth habit of the dominants, the site wetness, and the sample being one of the last to be collected. With a few notable exceptions the three plots follow one another as far as general configuration; however, when production is plotted against a decreasing stand continuum index (Figures 7 and 8) the general pattern breaks down and the deviations are quite apparent. Figure 7 shows a general increase in both standing and litter material as the continuum goes from dry to wet while Figure 8 shows production to be fairly constant or decreasing slightly.

A study of three relict prairies (two in Missouri and one in Iowa) by Koelling and Kucera (1965) showed that the amount of accumulated litter was inversely related to standing crop production which decreased from 543.5 g/m^2 (southwest Missouri) to 390.0 g/m^2 (northeast Iowa). Values for litter material ranged from 381.6 g/m^2 (southwest Missouri) to 510.0 g/m^2

(northeast Iowa). Biomass of standing crop for Sheeder Prairie was 447.7 g/m^2 with a litter value of 302.4 g/m^2. The standing crop value for Sheeder Prairie is of comparable magnitude in view of the geographic position of the prairie on a moisture gradient from southwest Missouri to northeast Iowa.

Stands 11 through 18 constitute the whole of transect 1 which is a fairly uniform, gentle nose slope while (stands 1 through 10) transect 2 ranges from a steep sideslope to a nearly level drainage way, to a steeper sideslope to a ridgetop. Stands on transect 2 that are on the dry end of the continuum would be more unstable, due to the degree of slope and subsequent erosive forces, than would stands on the wet end of the continuum which occur on gentler slopes to nearly level areas. The wetter areas would support species with rank growth habits while retarding litter decomposition. The length and time of year of the sampling period may provide a part of the explanation. Transect 1 was sampled over a period of 12 days from August 23 to September 4, 1968 and transect 2 over a 28 day period from September 21 to October 19, 1968 (Tables 7 and 8). The lateness and length of sampling on transect 2 would favor the slower growing, later maturing species such as Andropogon Gerardii. Had the sampling periods been shorter and more than one clipping done during the growing season, the difficulties encountered in interpretation would have been minimized to some extent.

Three-dimensional ordination of species using meter^2 plots as locations (Orloci, 1966) was disappointing. Species ordinated along the X, Y, and Z axis should have been related to some definable environment factor such as moisture or if not, then ideally grouped by slope position.

Presence data along with the slope-related m^2 plots were used in the ordination. Species ordination on the X-axis was by percent frequency. Neither the Y nor the Z axis could be related to any measured or implied factor for either transect. Species groupings along the X-axis and the coordinates for each of the three axes are presented in Table 15 and 16 (Appendix). Better results could have been obtained using cover data and presence together rather than presence alone. An independent estimate of environmental gradients such as soil moisture and pH would have been valuable in axis determinations.

SUMMARY

The study of tall-grass prairie vegetation relative to slope position on Sheeder Prairie, Iowa, yielded the following results and conclusions:

1. A plant list containing 54 families, 129 genera and 180 species was assembled. The three families most important in terms of number of species were Compositae, Gramineae, and Fabaceae.
2. The prairie unit was characterized as a tall-grass dominanted, mesic, upland prairie on the basis of (1) a mesic continuum index (327.4); (2) the occurrence of upland soil types (Sharpsburg, Shelby, Adair) and upland species (Ceanothus ovatus, Salix humilis); and (3) the high frequencies of tall-grass species (Andropogon Gerardii, A. scoparius, Stipa spartea, Sporobolus heterolepis, Sorghastrum nutans).
3. A stratified random sampling grid was arranged along two belt transects with species presence and dominance being recorded for m^2 plots. The transects were later broken up into 18 stands based on slope position and parent material. The deliniated parent materials relative to slope position were loess, late Sangamon paleosol, late Sangamon paleosol B_3, Kansan till, Aftonian paleosol, Nebraskan till, till-derived sediment over till and alluvium.
4. Eighteen stands were ordinated using the prairie continuum index of Curtis (1955) modified to use frequency data. By grouping stands on the basis of similar parent materials, six groups were obtained which were also ordinated using this method. Ordination of grouped parent materials from dry to wet was; loess, till, late Sangamon paleosol, Aftonian paleosol, till-derived sediment and alluvium. As the continuum is a measure of vegetation response to a moisture gradient, the

ordination of the 18 stands presented a complex picture related to degree of slope, aspect, parent material, and soil moisture.

5. The use of frequency values was effective in determining the continuum index of transect stands by giving species with high frequency more weight in the continuum calculation.

6. A species-importance value was calculated to characterize stands relative to species groups. This ordination proved to rather subjective in application even though the actual values were objective.

7. Production data were obtained from the clipped 20 cm x 50 cm plots. With slight differences in amplitude, the three plots follow the same general configurations; however, when biomass is plotted against decreasing continuum index the slope of transect 2 shows a general increase in both standing and litter material production while the slope of transect 1 shows a relatively constant to slightly decreasing amount of production. The difference in time of year and length of sampling period for the two transects seem to be the basis for the production differential. Values ranged from 115.0 g/m^2 to 1475.0 g/m^2 for standing crop and 30.0 g/m^2 to 965.0 g/m^2 for litter. Average production values for the prairie were 447.7 g/m^2 for standing crop and 302.4 g/m^2 for litter.

8. The use of presence data alone, in the three-dimensional ordination of Orloci (1966), resulted in a species ordination with the X-axis corresponding to the percent frequency. Neither the Y nor the Z axis gave indications of environmental relationships. It is suggested that the use of cover and presence data together would result in a more desirable ordination.

POSTSCRIPT

One tenent, basic to man's very existence and persistence on this planet, is that he must learn from his mistakes. It is hoped that through the information reported in this preliminary study of Sheeder Prairie, a base has been formed for continued research into the complexities of relict prairie vegetation.

The data in this study were collected over too long a sampling period and while presence determinations were adequate, additional quantities of information were desirable. Changes that would enhance the study conclusions and increase the amount of relatable data are: (1) the recording in sample plots of both presence and cover class data because cover data has a high correlation with the continuum, (2) a direct analysis of soil moisture for correlation with the continuum values, (3) re-definition of stands based on direct moisture values and parent materials, (4) analysis of change in pH and major soil nutrients relative to slope position and stands, (5) re-sampling of permanent plots at least three times during the growing season in order to sample seasonal aspects of the vegetation and soil regimes, (6) clipping of plots for production during three periods of the growing season by doing the clipping separate from presence and cover determinations to shorten the sample period from weeks to one or two days, (7) simplification of the species-importance index or the substitution of a more objective method, (8) detailed study of soils as to profile characteristics and stratigraphy.

LITERATURE CITED

Brown, D. 1954. Methods of surveying and measuring vegetation. Hurley, Berks, England, Commonwealth Bureau of Pastures and Field Crops Bulletin 42.

Clements, F. E. 1916. Plant succession. Carnegie Institute of Washington Publication 242.

Curtis, J. T. 1955. A prairie continuum in Wisconsin. Ecology 36: 558-566.

Curtis, J. T. 1959. The vegetation of Wisconsin. Madison, Wisconsin, University of Wisconsin Press.

Curtis, J. T. and G. Cottam. 1962. Plant ecology workbook. 3rd ed. Minneapolis, Minnesota, Burgess Publishing Company.

Curtis, J. T. and H. C. Green. 1949. A study of relic Wisconsin prairies by the species-presence method. Ecology 30: 83-92.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science 33: 43-64.

Ehrenreich, J. H. 1957. Management practices for maintenance of native prairie in Iowa. Unpublished Ph.D. Thesis. Ames, Iowa, Library, Iowa State University of Science and Technology.

Ehrenreich, J. H. and J. M. Aikman. 1963. An ecological study of the effect of certain management practices on native prairie in Iowa. Ecological Monographs 33: 113-130.

Freckman, R. W. 1966. The prairie remnants of the Ames area. Iowa Academy of Science Proceedings 73: 126-136.

Gleason, H. A. c1952. The new Britton and Brown illustrated flora. New York, N. Y., New York Botanical Garden.

Hayden, A. 1946. A progress report on the preservation of prairie. Iowa Academy of Science Proceedings 53: 45-82.

Hulett, G. K. and G. W. Tomanek. 1969. Remnant prairies on the shallow limey range site in North Central Kansas. Journal of Range Management 22: 19-23.

Jensen, P. N. and C. M. Schumacher. 1969. Changes in prairie plant composition. Journal of Range Management 22: 57-60.

Koelling, M. R. and C. L. Kucera. 1965. Productivity and turnover relationships in native tall-grass prairie. Iowa State Journal of Science 39: 387-392.

Landers, R. Q. 1966. Management of natural landscapes in Iowa: an appraisal. Iowa Academy of Science Proceedings 73: 155-160.

McComb, A. L. and W. E. Loomis. 1944. Subclimax prairie. Torrey Botanical Club Bulletin 71: 46-76.

Moyer, J. F. 1953. Ecology of native prairie in Iowa. Unpublished Ph. D. Thesis. Ames, Iowa, Library, Iowa State University of Science and Technology.

Oosting, H. J. c1956. The study of plant communities. 2d ed. San Francisco, California, W. H. Freeman.

Orloci, L. 1966. Geometric models in ecology. I. The theory and application of some ordination methods. Journal of Ecology 54: 193-215.

Oschwald, W. R., F. F. Riecken, R. I. Dideriksen, W. H. Scholtes, and F. W. Schaller. 1965. Principal soils in Iowa. Iowa State University of Science and Technology Cooperative Extension Service Special Report Number 42.

Pohl, R. W. 1966. The grasses of Iowa. Iowa State Journal of Science 40: 341-566.

Ruhe, R. V. and W. H. Scholtes. 1956. Ages and development of soil landscapes in relation to climatic and vegetational changes in Iowa. Soil Science Society of America Proceedings 20: 264-273.

Shantz, H. L. 1911. The natural vegetation as an indicator of the capabilities of land for crop production. U.S. Department of Agriculture Bureau of Plant Industry Bulletin 201.

Shimek, B. 1911. The prairies. University of Iowa Studies in Natural History Bulletin 6: 169-240.

Shimek, B. 1925. The persistence of the prairie. University of Iowa Studies in Natural History Bulletin 11: 3-24.

Transeau, E. N. 1935. The prairie peninsula. Ecology 16: 423-437.

Weaver, J. E. 1954. North American prairie. Lincoln, Nebraska, Johnson Publishing Company.

Weaver, J. E. 1958. Native grasslands of Southwestern Iowa. Ecology 39: 733-750.

Weaver, J. E. 1968. Prairie plants and their environment. Lincoln, Nebraska, University of Nebraska Press.

ACKNOWLEDGMENTS

I owe a deep debt of gratitude to fellow ecology graduate students for their willing and oft heated discussion of current ecological concepts and problems. A special note of thanks to A. H. (Herb) Huddleston for his invaluable analysis and patient discussion of the soils data; to Jack Brotherson for his help with the computer analysis; and to Dan Stoneburner for his provocative discussions concerning several aspects of this study.

A special thank you to all the students in my General Botany and Plant Ecology classes of the past two years for an immeasurable, yet substantial, contribution to my education and development as a teacher and an individual.

My sincere appreciation to Dr. Roger Q. Landers, Dr. Frank F. Riecken, and Dr. Donald Nevins for serving on my graduate committee. Special appreciation goes to Dr. Roger Q. Landers who headed my graduate committee, directed the research, corrected the manuscript and provided, through his insight, experience and attitude, an opportunity for the development of my own ideas and values.

To my wife, Julaine, a very special thank you for being a field companion, thesis typist, homemaker, morale booster, recreation director, financial wizard and for showing a distinct interest in my research and in ecology. This thesis is a direct product of her impatient yet understanding humanism.

I am also grateful to the Iowa State Conservation Commission for their financial support of this study during the past two summers and to the Iowa State University Graduate Research Fund for its support over the past two years.

APPENDIX

Table 14. List of species observed on Sheeder Prairie during 1968-69 arranged alphabetically by family and including common names

ACERACEAE	
Acer Negundo L.	Box Elder
AMARANTHACEAE	
Acnida tamariscina (Nutt.) Wood.	Water Hemp
Amaranthus retroflexus L.	Pigweed
AMARYLLIDACEAE	
Hypoxis hirsuta (L.) Cov.	Star Grass
ANACARDIACEAE	
Rhus radicans L.	Poison Ivy
APOCYNACEAE	
Apocynum sibiricum Jacq.	Indian Hemp
ASCLEPIADACEAE	
Asclepias tuberosa L.	Butterfly Weed
Asclepias syriaca L.	Common Milkweed
Asclepias verticillata L.	Whorled Milkweed
Asclepias viridiflora Raf.	Green Milkweed
BETULACEAE	
Corylus americana Walt.	Hazel
BORAGINACEAE	
Lithospermum canescens (Michx.) Lehm.	Hoary Puccoon
Onosmodium occidentale Mackenzie.	False Gromwell
CAESALPINIACEAE	
Cassia fasciculata Michx.	Partridge Pea
CAMPANULACEAE	
Campanula americana L.	Tall Bellflower
CAPRIFOLIACEAE	
Sambucus canadensis L.	Common Elder
CHENOPODIACEAE	
Chenopodium album L.	Lamb's Quarters
CISTACEAE	
Helianthemum Bicknellii Fern.	Frostweed
COMMELINACEAE	
Tradescantia bracteata Small.	Spiderwort

Table 14. (Continued)

COMPOSITAE	
Achillea Millefolium L.	Yarrow
Agoseris glauca (Pursh) D. Dietr.	Prairie False Dandelion
Ambrosia artemisiifolia L.	Common Ragweed
Ambrosia trifida L.	Giant Ragweed
Antennaria neglecta Green.	Pussy-toes
Antennaria plantaginifolia (L.) Richards.	Plantain-leaved Pussy-toes
Artemisia ludoviciana Nutt.	Mugwort
Aster azureus Lindl.	Azure Aster
Aster ericoides L.	Many-flowered Aster
Aster laevis L.	Smooth Aster
Aster sericeus Vent.	Silky Aster
Aster simplex Willd.	Simple Aster
Cacalia tuberosa Nutt.	Indian Turnip
Cirsium altissimum (L.) Spreng.	Thistle
Conyza canadensis (L.) Cron.	Horseweed
Coreopsis palmata Nutt.	Tickseed
Crepis sp. L.	Hawksbeard
Echinacea pallida Nutt.	Purple Coneflower
Erigeron strigosus Muhl.	Daisy Fleabane
Eupatorium rugosum Houtt.	White Snakeroot
Helenium amarum (Raf.) Rock.	Sneezeweed
Helianthus grosseserratus Martens.	Sunflower
Helianthus laetiflorus Pers.	Sunflower
Heliopsis helianthoides (L.) Sweet.	Ox-eye
Hieracium longipilum Torr.	Hawkweed
Kuhnia eupatorioides L.	False-boneset
Lactuca biennis (Moench) Fern.	Wild Lettuce
Lactuca canadensis L.	Wild Lettuce
Lactuca Serriola L.	Prickly Lettuce
Liatris aspera Michx.	Blazing-star
Liatris ligulistylis (A. Nels.) K. Schum.	Blazing-star
Liatris pycnostachya Michx.	Blazing-star
Liatris squarrosa (L.) Michx.	Blazing-star
Ratibida pinnata (Vent.) Barnh.	Yellow Coneflower
Senecio obovatus Muhl.	Groundsel
Silphium integrifolium Michx.	Rosin-weed
Silphium laciniatum L.	Compass-plant
Silphium perfoliatum L.	Cup-plant
Solidago canadensis L.	Goldenrod
Solidago gigantea Ait.	Goldenrod
Solidago missouriensis Nutt.	Missouri Goldenrod
Solidago rigida L.	Rigid Goldenrod
Solidago speciosa Nutt.	Goldenrod
Taraxacum officinale Weber.	Common Dandelion
Tragopogon dubius Scop.	Goatsbeard
Vernonia Baldwini Torr.	Ironweed

Table 14. (Continued)

CONVOLVULACEAE	
Convolvulus sepium L.	Hedge Bindweed
CORNACEAE	
Cornus stolonifera Michx.	Red Osier Dogwood
CRUCIFERAE	
Lepidium campestre (L.) R. Br.	Field Cress
Lepidium virginicum L.	Pepper-grass
CUCURBITACEAE	
Echinocystis lobata (Michx.) T. & G.	Wild Cucumber
CUPRESSACEAE	
Juniperus virginiana L.	Red Cedar
CYPERACEAE	
Carex sp. L.	Sedge
EQUISETACEAE	
Equisetum arvense L.	Common Horsetail
Equisetum kansanum Schaffner.	Horsetail
EUPHORBIACEAE	
Euphorbia corollata L.	Flowering Spurge
Euphorbia maculata L.	Wartweed
FABACEAE	
Amorpha canescens Pursh.	Lead-plant
Amphicarpa bracteata (L.) Fern.	Hog-peanut
Astragalus canadensis L.	Milk-vetch
Astragalus crassicarpus Nutt.	Ground Plum
Baptisia leucantha T. & G.	Prairie False Indigo
Baptisia leucophaea Nutt.	False Indigo
Desmodium illinoense Gray.	Tick-trefoil
Lespedeza capitata Michx.	Bush Clover
Melilotus alba Desr.	White Sweet Clover
Melilotus officinalis (L.) Desr.	Yellow Sweet Clover
Petalostemum candidum (Willd.) Micx.	White Prairie Clover
Petalostemum purpureum (Vent.) Rydb.	Prairie Clover
Psoralea argophylla Pursh.	Silver-leaved Scurf Pea
Psoralea esculenta Pursh.	Prairie Turnip
Trifolium pratense L.	Red Clover
GENTIANACEAE	
Gentiana puberula Michx.	Gentian
GRAMINEAE	
Agrostis alba L.	Redtop

Table 14. (Continued)

GRAMINEAE (Continued)	
Agrostis hiemalis (Walt.) B.S.P.	Ticklegrass
Andropogon Gerardii Vitman.	Big Bluestem
Andropogon scoparius Michx.	Little Bluestem
Bouteloua curtipendula (Michx.) Torr.	Side-oats Grama
Bromus inermis Leyss.	Smooth Brome
Bromus japonicus Thunb.	Japanese Brome
Bromus tectorum L.	Downy Chess
Elymus canadensis L.	Canada Wild Rye
Elymus virginicus L.	Virginia Wild Rye
Hordeum Jubatum L.	Squirrel-tail Barley
Koeleria cristata (L.) Pers.	June Grass
Leersia virginica Willd.	White Grass
Muhlenbergia racemosa (Michx.) B.S.P.	Muhly-grass
Panicum capillare L.	Witchgrass
Panicum implicatum Scribn.	Rosette panic-grass
Panicum leibergii (Vasey) Scribn.	Posette panic-grass
Panicum scribnerianum Nash.	Panicum
Panicum virgatum L.	Switchgrass
Phleum pratense L.	Timothy
Poa compressa L.	Canada Blue Grass
Poa pratensis L.	Kentucky Blue Grass
Setaria lutescens (Weigel) F.T. Hubb.	Yellow Foxtail
Sorghastrum nutans (L.) Nash.	Indian Grass
Spartina pectinata Link.	Sloughgrass
Sphenopholis obtusata (Michx.) Scribn.	Wedgegrass
Sporobolus asper (Michx.) Kunth.	Tall Dropseed
Sporobolus heterolepis (A. Gray) A. Gray	Prairie Dropseed
Stipa spartea Trin.	Porcupine Grass
HYPERICACEAE	
Hypericum sphaerocarpum Michx.	St. John's wort
IRIDACEAE	
Sisyrinchium campestre Bickn.	Blue-eyed Grass
LABIATAE	
Monarda fistulosa L.	Horsemint
Prunella vulgaris L.	Self-heal
Pycnanthemum virginianum (L.) Durand & Jackson.	Mint
LINACEAE	
Linum sulcatum Riddell.	Flax
LOBELIACEAE	
Lobelia spicata Lam.	Spike-lobelia

Table 14. (Continued)

MALVACEAE	
Hibiscus Trionum L.	Flower-of-an-hour
NYCTAGINACEAE	
Mirabilis hirsuta (Pursh) MacM.	Four-o'clock
OLEANCEAE	
Fraxinus americana L.	White Ash
ONAGRACEAE	
Gaura biennis L.	Biennial Gaura
Oenothera biennis L.	Evening Primrose
ORCHIDACEAE	
Spiranthes cernua (L.) Rich.	Common Lady's Tresses
OXALIALACEAE	
Oxalis europaea Jord.	Yellow Wood-sorrel
Oxalis stricta L.	Yellow Wood-sorrel
Oxalis violacea L.	Violet Wood-sorrel
POLEMONIACEAE	
Phlox pilosa L.	Prairie Phlox
POLYGONACEAE	
Polygonum pensylvanicum L.	Smartweed
Polygonum scandens L.	False Buckwheat
Rumex crispus L.	Sour Dock
PRIMULACEAE	
Lysimachia ciliata L.	Loosestrife
RANUNCULACEAE	
Anemone cylindrica Gray.	Thimbleweed
Delphinium virescens Nutt.	Larkspur
Ranunculus abortivus L.	Small-flowered Crowfoot
RHAMNACEAE	
Ceanothus ovatus Desf.	Redroot
ROSACEAE	
Fragaria virginiana Duchesne.	Wild Strawberry
Geum canadense Jacq.	Avens
Potentilla canadensis L.	Cinquefoil
Potentilla norvegica L.	Cinquefoil
Prunus americana Marsh.	Wild Plum
Prunus serotina Ehrh.	Black Cherry
Prunus virginiana L.	Choke Cherry
Rosa suffulta Greene.	Prairie Rose

Table 14. (Continued)

RUBIACEAE	
Galium Aparine L.	Bedstraw
Galium boreale L.	Northern Bedstraw
SALICACEAE	
Populus deltoides Marsh.	Cottonwood
Salix humilis Marsh.	Upland Willow
Salix nigra L.	Black Willow
SANTALACEAE	
Comandra umbellata (L.) Nutt.	Bastard Toad-flax
SCROPHULARIACEAE	
Pedicularis canadensis L.	Common Lousewort
Verbascum Thapsus L.	Mullein
Veronicastrum virginicum (L.) Farw.	Culver's Root
SOLANACEAE	
Physalis virginiana Mill.	Ground Cherry
Solanum nigrum L.	Black Nightshade
ULMACEAE	
Ulmus pumila L.	Siberian Elm
Ulmus rubra Muhl.	Slippery Elm
UMBELLIFERAE	
Eryngium yuccifolium Michx.	Rattlesnake-master
Pastinaca sativa L.	Wild Parsnip
Polytaenia Nuttallii DC.	
Sanicula marilandica L.	Black Snakeroot
Zizia aurea (L.) Koch.	Golden Alexanders
URTICACEAE	
Cannabis sativa L.	Hemp
Urtica dioica L.	Stinging Nettle
VERBENACEAE	
Verbena hastata L.	Blue Vervain
VIOLACEAE	
Viola sp. L.	Violet
Viola pedata L.	Bird-foot Violet
Viola pedatifida G. Don.	Prairie Violet
VITACEAE	
Parthenocissus quinquefolia (L.) Planch.	Virginia Creeper
Vitis riparia Michx.	Frost-grape

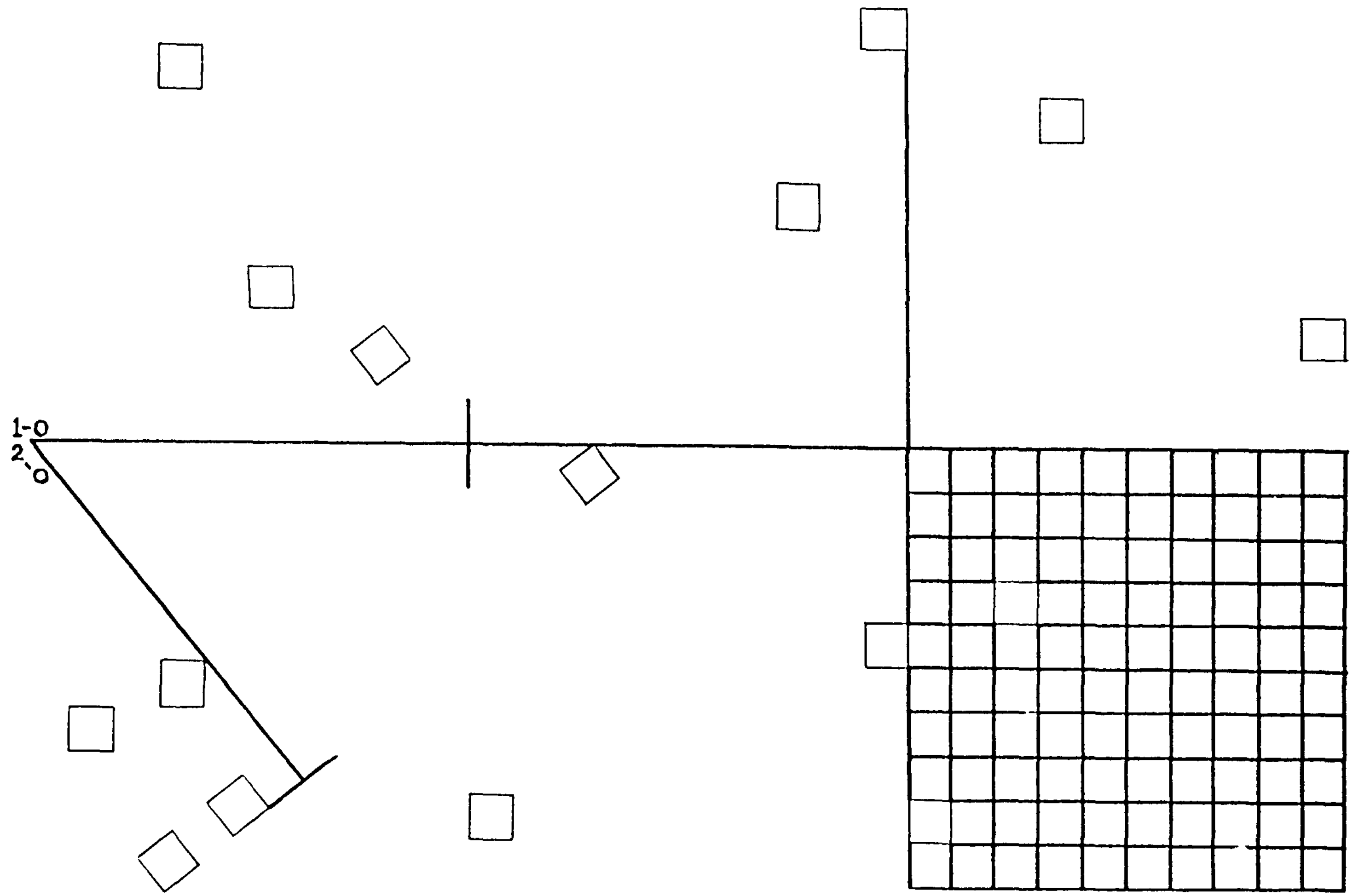

Figure 9. Actual placement of m^2 plots through the first 30 meters on transect 1 and the first 10 meters on transect 2 where each square equals an area of 1 m^2

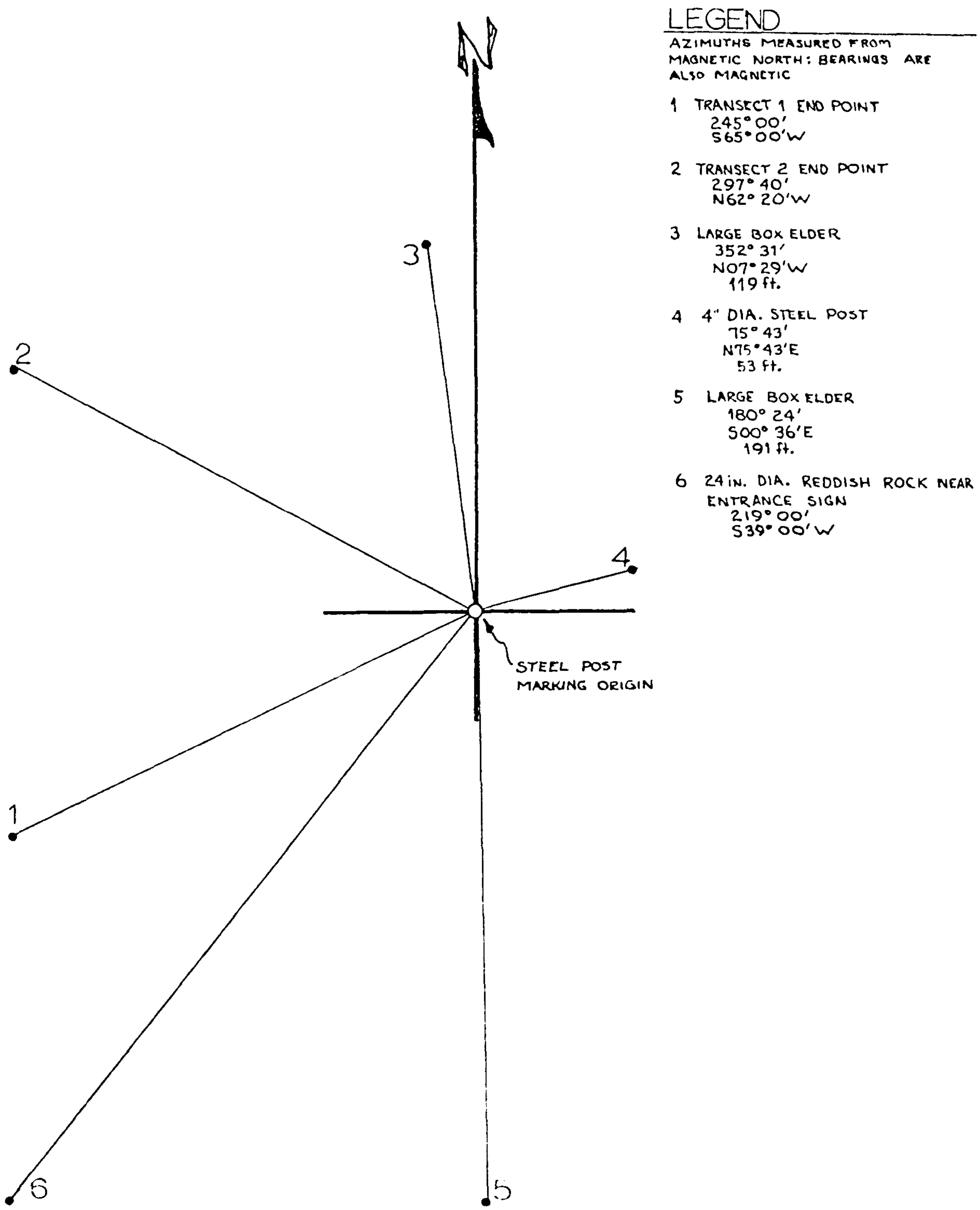

Figure 10. Azimuths and bearings for six stations relative to the location of the common origin for transects 1 and 2 including linear distances to the three nearest stations

Table 15. Ordination of selected species by percent frequency along the X-axis of an X Y plot using coordinates obtained from the Q-analysis of Orloci for transect 1

Species[a]	Frequency %	Coordinates		
		X	Y	Z
Panicum leibergii	89.8	9.000	0.000	-0.668
Amorpha canescens	80.7	8.000	1.084	-0.668
Stipa spartea	84.1	7.889	0.983	0.208
Andropogon scoparius	63.6	6.222	0.467	-0.931
Euphorbia corollata	64.8	6.111	-0.231	-0.263
Phlox pilosa	70.5	6.556	0.968	-0.931
Sporobolus heterolepis	54.5	5.778	0.263	-0.200
Zizia aurea	67.0	6.000	-0.531	-0.893
Andropogon Gerardii	48.9	4.444	-0.150	0.121
Antennaria neglecta	38.6	4.111	0.742	-1.100
Echinacea pallida	44.3	4.444	5.025	-0.668
Poa compressa	42.0	3.778	-0.157	-0.918
Silphium integrifolium	46.6	4.111	0.145	0.793
Cassia fasciculata	36.4	3.333	0.435	-0.427
Hieracium longipilum	35.2	3.556	0.835	-0.836
Petalostemum candidum	30.7	3.444	0.536	-1.115
Poa pratensis	33.0	3.000	0.332	-1.127
Aster laevis	25.0	2.667	0.428	-1.687
Ceanothus ovatus	25.0	2.778	1.125	-1.642
Coreopsis palmata	26.1	2.667	0.826	-0.965
Panicum implicatum	27.3	3.111	0.631	-0.618
Ratibida pinnata	27.3	2.444	1.221	-1.124
Viola pedatifida	25.0	2.889	0.828	-2.036
Viola pedata	23.9	2.778	0.926	-2.297
Koeleria cristata	23.9	2.333	0.722	-1.392
Potentilla norvegica	22.7	2.222	0.622	-1.328
Solidago canadensis	20.5	2.333	0.722	-1.470
Lespedeza capitata	18.2	2.111	0.919	-1.799
Linum sulcatum	17.0	2.000	1.017	-1.571

[a]Only species which had frequencies above 5% or were dominant in one or more plots were included in this ordination study.

Table 15. (Continued)

Species	Frequency %	Coordinates		
		X	Y	Z
Antennaria plantaginifolia	13.6	1.778	1.015	-1.312
Aster ericoides	15.9	1.667	0.914	-1.603
Aster sericeus	14.8	1.667	0.914	-1.679
Carex sp.	13.6	1.556	0.614	-1.572
Elymus canadensis	13.6	1.667	1.113	-1.603
Liatris squarrosa	11.4	1.556	1.012	-1.725
Oenothera biennis	14.8	1.444	0.713	-1.133
Artemisia ludoviciana	08.0	1.111	0.410	-1.291
Bouteloua curtipendula	10.2	1.444	0.912	-1.611
Cirsium altissimum	10.2	1.444	0.713	-1.611
Eryngium yuccifolium	09.1	1.333	0.612	-1.642
Fragaria virginiana	08.0	1.000	0.509	-1.053
Hordeum Jubatum	08.0	1.222	0.710	-1.192
Monarda fistulosa	09.1	0.889	0.408	-0.709
Salix humilis	06.8	1.111	0.609	-1.210
Silphium laciniatum	09.1	1.333	1.010	-1.642
Ambrosia artemisiifolia	04.5	0.889	0.607	-0.884
Gaura biennis	05.7	0.778	1.302	-1.047
Helianthemum Bicknellii	05.7	1.000	0.708	-0.883
Lactuca biennis	05.7	0.889	1.403	-1.301
Lactuca Serriola	04.5	0.778	0.506	-1.130
Oxalis europaea	05.7	0.667	0.803	-0.773
Rosa suffulta	04.5	0.889	0.806	-1.381
Ambrosia trifida	02.3	0.222	0.600	-0.528
Heliopsis helianthoides	04.5	0.444	0.204	-0.624
Prunus americana	06.8	0.333	0.501	-0.489
Elymus virginicus	06.8	0.000	-0.000	0.000

Table 16. Ordination of selected species by percent frequency along the X-axis of an X Y plot using coordinates obtained from the Q-analysis of Orloci for transect 2

Species[a]	Frequency %	Coordinates		
		X	Y	Z
Stipa spartea	92.9	10.000	0.000	0.573
Panicum leibergii	83.9	8.713	0.192	0.514
Andropogon scoparius	61.6	6.139	0.803	0.230
Phlox pilosa	51.8	5.248	0.138	0.323
Zizia aurea	55.4	5.347	0.963	0.088
Euphorbia corollata	41.1	4.357	0.185	-0.828
Ratibida pinnata	42.9	4.258	0.427	-1.257
Elymus canadensis	38.4	3.664	5.619	-1.560
Silphium integrifolium	37.5	3.565	0.345	-1.316
Sporobolus heterolepis	38.4	4.159	-0.932	-1.126
Amorpha canescens	33.0	3.466	-0.302	-1.830
Carex sp.	28.6	0.495	0.567	-0.803
Echinacea pallida	27.7	2.970	-0.869	-1.919
Sorghastrum nutans	31.3	3.466	-0.124	-2.291
Aster ericoides	24.1	2.574	0.635	-2.020
Ceanothus ovatus	25.9	2.871	0.441	-2.149
Poa compressa	24.1	2.673	0.570	-2.903
Andropogon Gerardii	22.3	2.178	1.071	-2.295
Aster laevis	17.0	1.782	0.084	-1.348
Petalostemum candidum	19.6	2.079	-0.110	-2.172
Poa pratensis	19.6	1.782	1.151	-2.088
Antennaria neglecta	11.6	1.118	-0.063	-1.036
Cassia fasciculata	16.1	1.386	0.876	-1.461
Coreopsis palmata	14.3	1.485	0.277	-2.237
Gaura biennis	11.6	1.188	0.827	-1.807
Lespedeza capitata	12.5	1.188	0.827	-1.738
Rosa suffulta	12.5	1.287	-0.122	-2.017
Solidago speciosa	13.4	1.386	0.876	-1.810

[a]Only species with frequencies above 5% or which were dominant in one or more plots were included in this ordination study.

Table 16. (Continued)

Species	Frequency %	Coordinates		
		X	Y	Z
Artemisia ludoviciana	10.7	1.188	0.649	-1.339
Aster sericeus	09.3	1.089	0.180	-2.002
Bouteloua curtipendula	09.8	0.990	0.778	-1.780
Cirsium altissimum	10.7	0.891	1.199	-0.988
Equisetum sp.	07.1	0.792	0.729	-1.082
Eryngium yuccifolium	08.0	0.891	0.309	-1.702
Fragaria virginiana	08.0	0.693	0.260	-1.045
Heliopsis helianthoides	07.1	0.693	0.616	-0.978
Hieracium longipilum	08.0	0.891	0.131	-1.393
Koeleria cristota	10.7	1.188	0.115	-1.734
Linum sulcatum	08.0	0.792	0.017	-1.260
Muhlenbergia racemosa	09.8	0.891	1.199	-1.214
Panicum implicatum	08.0	0.891	-0.047	-1.771
Salix humilis	09.8	0.990	-0.290	-1.499
Silphium laciniatum	07.1	0.792	0.373	-1.535
Viola pedata	10.7	1.089	0.002	-1.190
Antennaria plantaginifolia	04.5	0.495	0.033	-1.203
Desmodium illinoense	04.5	0.495	0.567	-0.803
Elymus virginicus	04.5	0.396	0.454	-0.664
Helianthemum Bicknellii	04.5	0.396	-0.080	-0.561
Kuhnia eupatorioides	04.5	0.495	0.567	-0.959
Liatris squarrosa	05.4	0.594	0.147	-1.131
Oxalis europaea	04.5	0.495	0.745	-1.388
Rhus radicans	04.5	0.495	0.389	-0.958
Solidago canadensis	05.4	0.990	-0.290	-1.499
Vernonia Baldwini	04.5	0.396	0.810	-0.789
Baptisia leucophaea	01.8	0.198	0.227	-0.580
Potentilla norvegica	01.8	0.000	-0.000	0.000